Appendix C

Preremediation Sampling Summary Report

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TABLES

ACRONYMS

CEL	Chemical Engineering Laboratory
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (42 USC § 9601 et seq., 1980)
CFA	Central Facilities Area
CFR	Code of Federal Regulations
CFVAFS	cold vapor atomic fluorescence spectrometry
DOE-ID	U.S. Department of Energy Idaho Operations Office (old designation, now DOE Idaho)
EPA	U.S. Environmental Protection Agency
ICDF	INEEL CERCLA Disposal Facility
ID	identification
INEEL	Idaho National Engineering and Environmental Laboratory
OU	operable unit
ROD	Record of Decision
TCLP	toxicity characteristic leaching procedure
TPR	technical procedure
WAG	waste area group

Preremediation Sampling Summary Report

C-1. OVERVIEW

Preremediation sampling of the Central Facilities Area (CFA) -04 mercury pond was performed during the summer of 2002 in accordance with the *Field Sampling Plan for the Pre-Remediation Sampling of the Central Facilities Area-04 Pond* (DOE-ID 2002a). The governing quality assurance project plan for the sampling effort was the *Quality Assurance Project Plan for Waste Area Groups 1, 2, 3, 4, 5, 6, 7, 10, and Inactive Sites* (DOE-ID 2002b). The primary purpose of the sampling effort was to refine the definition of the vertical extent of contamination to provide better direction for the remediation excavation effort. In addition, it was necessary to obtain additional data to determine the final treatment and/or disposal of contaminated soil to be excavated from the CFA-04 pond during the remedial activities. Finally, the data will be used to determine whether the assumptions used in calculating the preliminary remediation goals are valid.

C-2. SITE BACKGROUND

C-2.1 Site Description

The Idaho National Engineering and Environmental Laboratory (INEEL) is a government-owned/contractor-operated facility managed by the U.S. Department of Energy Idaho Operations Office (DOE Idaho) and is located 51 km (32 mi) west of Idaho Falls, Idaho (Figure C-1). This facility occupies 2,305 km^2 (890 mi^2) of the northeastern portion of the Eastern Snake River Plain and encompasses portions of five Idaho counties: (1) Butte, (2) Jefferson, (3) Bonneville, (4) Clark, and (5) Bingham.

The CFA has been used since 1949 to house many of the support services for all of the operations at the INEEL. These support services include laboratories, security operations, fire protection, medical facilities, communication systems, warehouses, a cafeteria, vehicle and equipment pools, the bus system, and laundry facilities. The *Federal Facility Agreement and Consent Order for the Idaho National Engineering Laboratory* (DOE-ID 1991) identified 52 potential release sites at CFA, which were designated as Waste Area Group (WAG) 4. The types of Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites at WAG 4 include landfills, underground storage tanks, aboveground storage tanks, dry wells, disposal ponds, soil contamination sites, and a sewage plant. Each of these sites was placed into one of 13 operable units (OUs) within the WAG, based on similarity of contaminants, environmental release pathways, and/or investigations.

The CFA-04 pond is a shallow, unlined surface depression that was originally a borrow pit for construction activities at CFA (Figure C-2). The pond is approximately 46 × 152 m (150 × 500 ft) and roughly 2 to 2.4 m (7 to 8 ft) deep. Basalt outcrops are present within, and immediately adjacent to, the pond. It received laboratory waste from the Chemical Engineering Laboratory (CEL) in Building CFA-674 between 1953 and 1969. The CEL was used to conduct calcine experiments on simulated nuclear waste. The calcining process was later used on actual nuclear waste at the INEEL to change the waste from a liquid to a solid, thereby reducing the overall waste. The CEL experiments used mercury to dissolve simulated aluminum fuel cladding as well as radioisotope tracers in the calcining process. The primary waste streams discharged to the pond from the CEL included approximately 76.5 m^3 (100 yd^3) of mercury-contaminated calcine that contained low-level radioactive waste and liquid effluent from the laboratory experiments. In addition, there is approximately 382 m^3 (500 yd^3) of rubble consisting of laboratory bottles, asphalt and asbestos roofing materials, reinforced concrete, and construction and demolition debris. The pond received run-off from the CFA site periodically between 1953 and 1995.

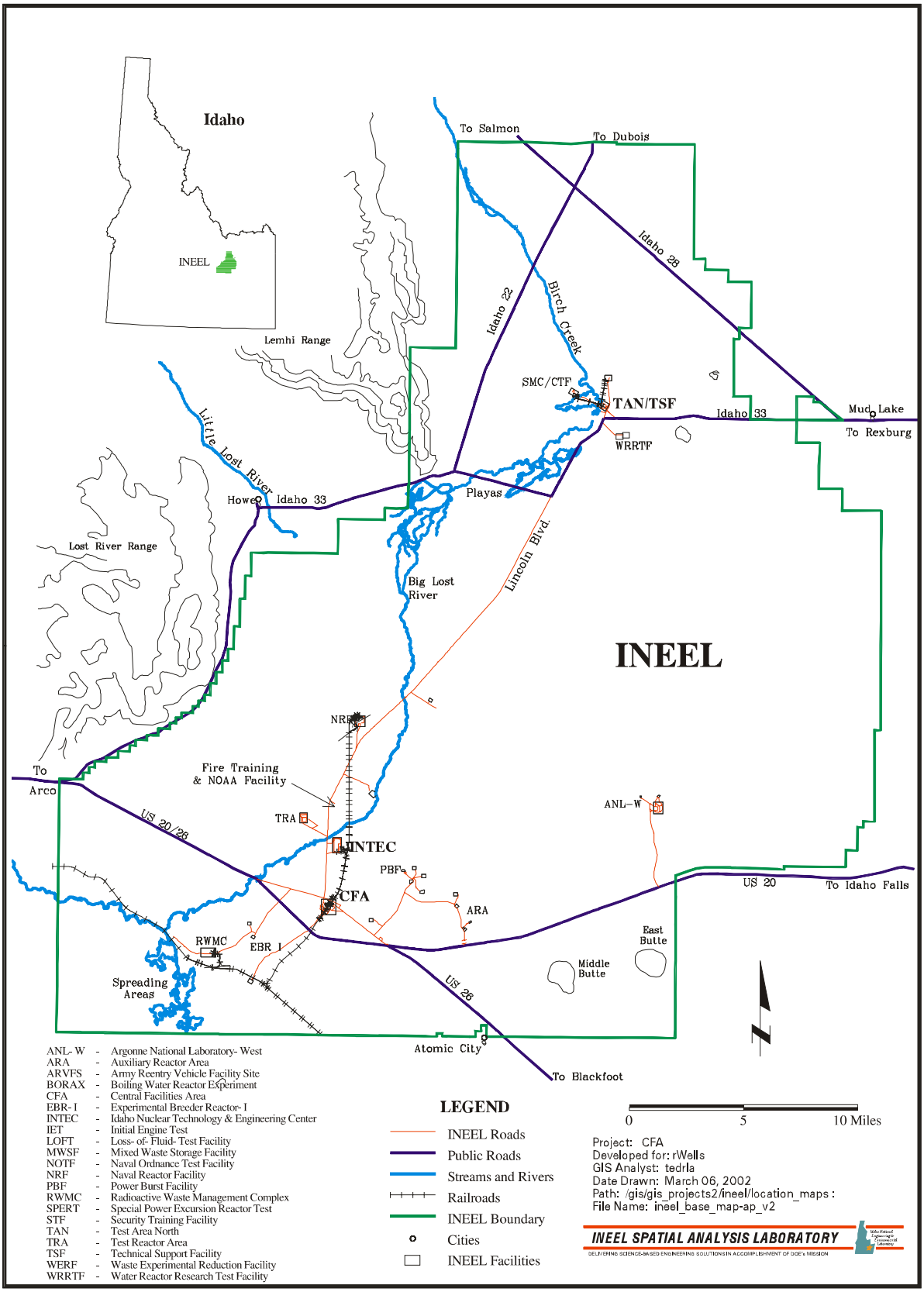

Figure C-1. Idaho National Engineering and Environmental Laboratory.

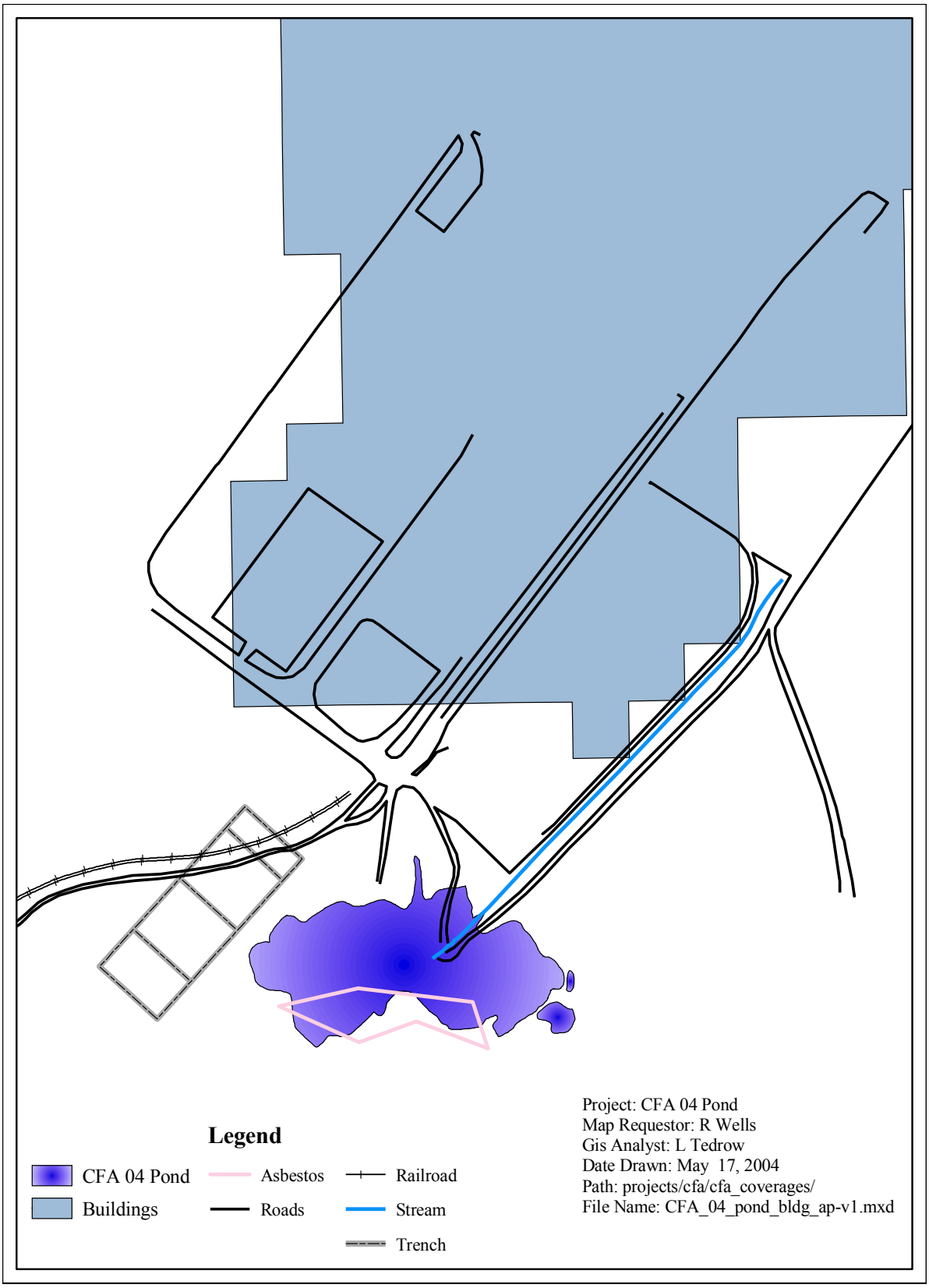

Figure C-2. Central Facilities Area, CFA-04 pond.

C-2.2 Nature and Extent of Contamination

The CFA-04 pond was identified as a Track 2 investigation site in the Federal Facility Agreement and Consent Order (DOE-ID 1991). In 1994, visual inspections revealed the presence of calcine on the bermed areas around the periphery of the pond. After surface and subsurface soil data collection from the calcine and the pond berm in early and mid-1994, a time-critical removal action in September 1994 excavated approximately 218 m^3 (285 yd^3) of calcine and calcine-contaminated soil and a small amount of asbestos from the bermed area. The soil was remediated at a portable retort setup northeast of the pond. Verification soil sampling conducted after the removal action showed that, with the exception of one location having a mercury concentration of 233 mg/kg, the bermed areas had residual mercury concentrations less than the final remediation goal of 8.4 mg/kg (DOE-ID 2000a).

The *Final Comprehensive Record of Decision for Central Facilities Area Operable Unit 4-13* (DOE-ID 2000b) originally established a final remediation goal of 0.5 mg/kg for mercury contamination at CFA-04. This was an ecological goal based on 10 times the average background concentration for composite samples. After new information became available from U.S. Environmental Protection Agency (EPA) sources, it was determined that a reevaluation of the final remediation goal for mercury was warranted for both human and ecological receptors. Based on this new information, hazard quotients were recalculated for the existing concentration of mercury at the CFA-04 pond. For the future residential exposure scenario, the recalculated hazard quotient is 7.56 as compared to 80 from the Record of Decision (ROD) (DOE-ID 2000b). For the ecological risk assessment, the recalculated values are <1 to 210 as compared to <1 to 30,000 from the ROD (DOE-ID 2000b). Based on this new information, the recalculated remediation goals for ecological and human health risk are 8.4 mg/kg and 9.4 mg/kg, respectively. The recalculated remediation goals for both human health and ecological receptors are consistent with the remedial action objectives for the CFA-04 pond. This information is presented in more detail in the *Explanation of Significant Differences to the Record of Decision for the Central Facilities Area, Operable Unit 4-13* (DOE-ID 2003).

During the 1995 Track 2 investigation, additional soil samples were collected from the pond inlet area and a deeper area of the pond near the inlet where laboratory effluent might have collected. The results of the 1994 and 1995 soil investigations revealed that concentrations of the following constituents exceeded background concentrations for the INEEL: aluminum, arsenic, barium, cadmium, calcium, chromium, cobalt, lead, magnesium, mercury, nickel, Cs-137, Pa-234m, Sr-90, Th-234, U-234, U-235, and U-238. Aroclor-1254 also was detected at low levels. Preliminary risk screening indicated that the following constituents detected at the pond posed potential human health risks: aroclor-1254, arsenic, mercury, Cs-137, U-234, U-235, and U-238. The range of detected concentrations of these analytes is presented in Table C-1. Based on these data, the site was recommended in the *Preliminary Scoping Track 2 Summary Report for Operable Unit 4-05* (Blackmore, Peatross, and Stepan 1996) for further characterization in the *Comprehensive Remedial Investigation/Feasibility Study for the Central Facilities Area Operable Unit 4-13 at the Idaho National Engineering and Environmental Laboratory* (DOE-ID 2000a).

Table C-1. Range of detected concentrations.

Analyte	Range of Detected Concentrations
Arsenic	3.1 to 22.4 mg/kg
Mercury	0.12 to 439 mg/kg
Cs-137	0.0742 to 2 pCi/g
U-234	0.651 to 22.6 pCi/g
U-235	0.0225 to 1.6 pCi/g
U-238	0.73 to 35 pCi/g

During 1997 and 1998, additional soil samples were collected for the OU 4-13 Remedial Investigation/Feasibility Study at four areas along the length of the pipe connecting the CEL to the pond, in the area northeast of the pond known as the windblown area, and from the pond bottom. Data from these investigations confirmed the presence of mercury in these areas at concentrations up to 439 mg/kg (DOE-ID 1992). Four of the 88 samples exceeded the mercury Resource Conservation and Recovery Act (42 USC § 6901 et seq., 1976) (RCRA) characteristic hazardous waste level of 0.2 mg/L. Three of the four samples were in close proximity to one another in the pond, and the fourth was an isolated occurrence in the windblown area and was eliminated. A contour line was drawn around the three closely spaced samples and the area was estimated. The depth of the soil in the pond conservatively was estimated to be 2.4 m (8 ft) in the pond bottom and 0.15 m (0.5 ft) in the windblown area, indicating that approximately 612 m^3 (800 yd^3) of soil is potentially characteristic waste in accordance with the Resource Conservation and Recovery Act and is subject to land disposal restrictions upon excavation.

During the summer of 2002, sampling was performed within the contours of the pond and at selected areas outside the pond that were determined, based on historical analytical data, to contain higher mercury concentrations. This sampling was performed to further refine the vertical extent of contamination to provide better direction for the remediation excavation effort. The collection of samples also served to determine the final treatment and/or disposal options for the contaminated soil excavated from the pond and to determine whether the assumptions used in calculating the final remediation goals were valid.

The only contaminant that poses an unacceptable risk to human health and the environment is mercury. Mercury-contaminated soil is present in the pond bottom, around the pond periphery in the berms, along the pipe connecting the CEL to the pond, and in the area northeast of the pond as a result of windblown contamination. This contamination encompasses an area approximately 91 × 183 m (300 × 600 ft). The OU 4-13 Remedial Investigation/Feasibility Study (DOE-ID 2000a) conservatively estimated the volume of mercury-contaminated soil to be approximately 6,338 m^3 (8,290 yd^3), based on the dimensions of the pond bottoms, windblown area, and pipeline at depths of 2.4 m (8 ft), 0.15 m (0.5 ft), and 1.8 m (6 ft), respectively. This volume was calculated using the extent of contamination based on the original final remediation goal of 0.50 mg/kg for total mercury as stated in the ROD (DOE-ID 2000b). The final volume could differ based on the revised final remediation goal of 8.4 mg/kg and actual conditions encountered in the field.

C-2.3 Project Description

Significant data previously have been collected defining much of the areal and vertical extent of mercury contamination in the CFA-04 pond (refer to the Field Sampling Plan, Appendix A [DOE-ID 2002a]). Particularly, adequate information is available detailing the contamination levels in the pond's surficial soil, much of the bermed area, and the surficial soil in the windblown area. However, data gaps still exist in the definition of the vertical extent of contamination in the pond area and the bermed area along the southern edges of the pond. Additional sampling for mercury analysis was deemed necessary to aid in soil excavation during the remedial action in an effort to minimize the volume of contaminated soil requiring disposal.

Chromium and silver have been detected in soil samples collected from the pond at maximum concentrations of 237 mg/kg and 121 mg/kg, respectively. Applying the 20X rule of dilution to the total metal results provides a conservative estimate of 11.8 mg/L and 6.0 mg/L, respectively, both of which exceed the characteristic limits of 6.0 mg/L for both chromium and silver. Therefore, it was necessary to determine whether any of the soils to be remediated for mercury contamination are characteristic for either chromium or silver, as this will affect the final disposal pathway.

Likewise, there is some soil that exceeds background concentrations for radionuclides. If soil exceeds background concentrations for radionuclides, then it must be disposed of at the INEEL CERCLA Disposal Facility (ICDF); otherwise, it can be disposed of at the CFA landfill. If the soil also exceeds the 260-mg/kg regulatory limit for mercury, then the soil would require off-Site treatment by retort (40 CFR 268.40, "Applicability of Treatment Standards").

As it is the intent of the CFA-04 project to dispose of the contaminated soil at the ICDF, data were required to support the waste acceptance criteria for that facility. The data generated from this sampling effort will be used to define a three-dimensional representation of the contamination zones within the CFA-04 pond. The data ultimately will be used to direct the soil excavation during the remedial action. This three-dimensional representation will describe the vertical extent of contamination within each zone defined in the Field Sampling Plan (DOE-ID 2002a), thereby allowing the project to determine the required excavation depth within the areal boundary of a zone.

Lastly (as previously described), the final remediation goal was reevaluated with 8.4 mg/kg total mercury being defined as the cleanup goal based on ecological risk. The primary risk due to mercury is attributed to the presence of methyl mercury. It must be determined whether the concentrations of methyl mercury in the pond are less than or equal to those used in calculating the ecological risk. If the methyl mercury concentrations are greater, then the final remediation goal may need to be revisited.

C-3. SAMPLING LOCATIONS

Samples were collected representing 30-cm (1-ft) intervals. As an example, the basalt underlying a given zone may be 1.83 m (6 ft) deep. Four cores were collected within the zone, and samples of each core were collected from 0 to 30 cm (0 to 1 ft), 30 to 61 cm (1 to 2 ft), 61 to 91 cm (2 to 3 ft), 91 cm to 1.22 m (3 to 4 ft), 1.22 to 1.52 m (4 to 5 ft), and 1.52 to 1.83 m (5 to 6 ft). The 0- to 30-cm (0- to 1-ft) samples of each core were combined to provide one composite analytical sample that was submitted to the laboratory, as were the samples from each of the other depth intervals. Only the cores that reached a given depth interval were used to form the composite analytical sample for that interval. For example, if two cores reached a depth of 2.44 m (8 ft), those two cores were used to create the composite sample for that depth.

For sampling purposes, the CFA-04 pond area was subdivided into 15 zones (see Figure C-3). The zones were defined based on the source of contamination and similarity of mercury concentrations from historical sampling events. For all zones within the pond area, the sources of contamination were assumed to be waste calcine disposed of to the pond, as well as mercury-containing waste water that was pumped to the pond and allowed to percolate down through the pond sediments. Figure C-3 graphically delineates the sampling zones and the four core locations originally proposed within each zone.

C-4. SAMPLING REQUIREMENTS

As shown in Figure C-2, the area sampled was subdivided into zones. Each zone required four core samples with each core sample collected from the surface until the auger met refusal at the basalt interface. The basalt underlying the pond is fairly undulating—ranging in depth from the basalt outcroppings visible on the southern edge of the pond to an approximate depth of 3 m (10 ft) in a few locations. Following the collection of the core, samples were subdivided from the core at set intervals. The analytical sample submitted to the laboratory consisted of a composite of the individual core samples collected from a discrete depth within a given zone.

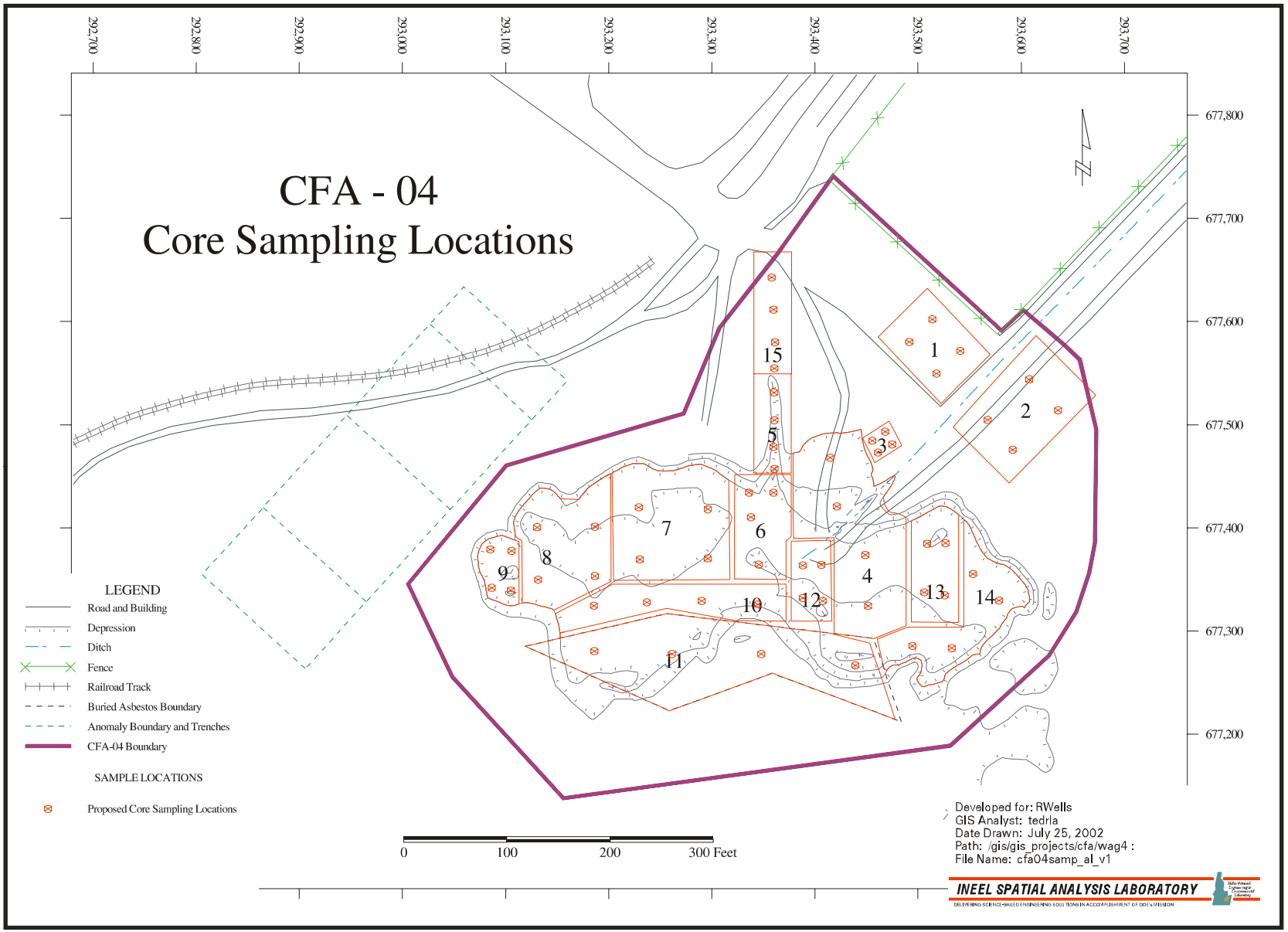

Figure C-3. Central Facilities Area, CFA-04 sampling locations.

Samples were collected following the procedures delineated in Technical Procedure (TPR) -6559, "Sampling with a Hollow-Stem Auger," as well as the requirements set forth in the subcontractor's scope of work and specifications. Much of the area sampled previously had been covered with a 15- to 30-cm (6- to 12-in.) layer of gravel. Before sampling at a given location, the gravel layer was removed by hand digging prior to using the drill auger. The gravel layer did not require sampling, since it was emplaced in 2001 as a fire mitigation method and was not contaminated in the same manner as the pond sediments.

The auger was equipped with a core catcher, a split inner barrel, and a Lexan liner. Initially, the auger was advanced approximately 0.9 m (3 ft) or until refusal, whichever occurred first. Because the core recoveries were poor for the initial sampling zones (1 and 2), a different sampling approach was taken for the subsequent zones. For Zones 3 through 15, the first 0- to 0.3-m (0- to 1-ft) interval was augered by hand, followed by mechanically augering in 0.3-m (1-ft) increments.

When mechanically augering, the inner split barrel was recovered with a wireline and the liner was retrieved. After removing the inner barrel shoe and head, both ends of the liner were capped and taped for delivery to the sampling team. A new liner was installed inside an inner barrel with associated ends and inside augers. The next 0.9-m (3-ft) section of the borehole was augered with these steps, continuing until refusal was encountered at the basalt interface. After the final core section was removed from the borehole, the borehole was backfilled with residual sample material or uncontaminated gravel or sand.

The sampling team collected individual sample aliquots using disposable sampling spoons. The aliquots were placed in certified, precleaned sample containers with an appropriate sample label affixed that had been obtained from Sampling and Analysis Management (formerly the Sample Management Office). Refer to Table C-2 for the specific sample analytical requirements.

Table C-2. Specific sample analytical requirements.

Analytical Parameter	Analytical Method
Hg/Cr/Ag	SW-846 EPA Method 7000 series[a]
Toxicity characterization leaching procedure Hg/Cr/Ag	SW-846 EPA Method 1311/ 7000 series[b]
Radionuclides	
Uranium isotopes	Alpha spectrometry
Strontium-90	Gas-flow proportional counting
Gamma-emitting isotopes	Gamma spectrometry
Methyl mercury	EPA Method 1630[c]

a. EPA Method, *Test Methods for Evaluating Solid Wastes: Physical/Chemical Methods,* SW-846 online, 7000 Series, http://www.epa.gov/epaoswer/hazwaste/test/7_series.htm, U.S. Environmental Protection Agency, Web Site visited May 19, 2004.

b. EPA Method 1311, 1992, *Test Methods for Evaluating Solid Wastes: Physical/Chemical Methods,* SW-846 Online, "Toxicity Characteristic Leaching Procedure," Rev. 0, U.S. Environmental Protection Agency, July 1992, URL: http://www.epa.gov/epaoswer/hazwaste/test/7_series.htm, Web Site visited May 19, 2004.

c. EPA Method 1630, 1998, "Methyl Mercury in Water by Distillation, Aqueous Ethylation, Purge and Trap, and CVAFS (Draft)," U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology, Engineering and Analysis Division, Washington, D.C., August 1998.

EPA = U.S. Environmental Protection Agency

C-4.1 Methyl Mercury Analytical Method

The samples were analyzed according to a modified version of EPA Method 1630, "Methyl Mercury in Water by Distillation, Aqueous Ethylation, Purge and Trap, and CVAFS (Draft)."[a] The EPA method was modified by leaching methyl mercury into a solution of KBr, H_2SO_4, and $CuSO_4$ and extracting it with CH_2CI_2—as was done by Bloom, Colman, and Barber (1997)—instead of steam distillation. The prescribed distillation technique would not work on these samples. The method also was modified for the analysis of methyl mercury by using purge and trap/gas chromatography/cold vapor atomic adsorption instead of cold vapor atomic fluorescence spectrometry (CVAFS). The extract was ethylated according to EPA Method 1630. The details of the steps performed are included in Attachment 1.

C-5. ANALYTICAL RESULTS

The following subsections summarize the sampling and analysis results for each of the 15 zones delineated in Figure C-3. A discussion is provided pertaining to the depth of individual core samples within each zone with the analytical results summarized for each depth sampled within the zone.

C-5.1 Sampling Zone 1

Four coreholes were drilled in Sampling Zone 1, ranging from 3.5 to greater than 3.7 m (11.5 to 12 ft). Three of the four coreholes were drilled to a depth greater than 3.66 m (12 ft); however, samples only were collected from the 0.3-m (1-ft) intervals down to the 3.7-m (12-ft) depth.

- Corehole 1-A-1
  - Depth—3.5 m (11.5 ft)
  - No sample was recovered for the 0.6- to 0.9-m (2- to 3-ft), 0.9- to 1.2-m (3- to 4-ft), and 2.7- to 3.0-m (9- to 10-ft) intervals
- Corehole 1-B-2
  - Depth—4.9 m (16 ft)
  - No sample was recovered for the 0.6- to 0.9-m (2- to 3-ft) and 1.5- to 1.8-m (5- to 6-ft) intervals
- Corehole 1-C-3
  - Depth—>3.7 m (12 ft)
  - No sample was recovered for the 0.9- to 1.2-m (3- to 4-ft), 1.2- to 1.5-m (4- to 5-ft), and 1.5- to 1.8-m (5- to 6-ft) intervals
- Corehole 1-D-4

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a. EPA, 1998, "Methyl Mercury in Water by Distillation, Aqueous Ethylation, Purge and Trap, and CVAFS (Draft)," Method 1630, U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology, Engineering and Analysis Division, Washington, D.C., August 1998.

- Depth—>3.7 m (12 ft)
- Full recovery occurred at all depths.

The analytical results for Sample Zone 1 are presented in Table C-3. Samples were analyzed for radionuclides (including gamma-emitting isotopes, strontium-90, and uranium isotopes), total mercury, and toxicity characteristic leaching procedure (TCLP) metals (including chromium, mercury, and silver). In addition, one sample collected from the 0- to 0.3-m (0- to 1-ft) interval also was analyzed for methyl mercury. As can be seen from the analytical results, none of the total mercury analytical results exceeded the final remediation goal of 8.4 mg/kg. Likewise, none of the three metals analyzed by TCLP exceeded the maximum concentrations for the toxicity characteristic, as provided in 40 CFR 261.24, "Toxicity Characteristic." Concentrations of uranium isotopes are in line with what would be expected naturally. Cesium-137 was detected in one sample collected from the 0- to 0.3-m (0- to 1-ft) interval; however, the concentration is less than the 95% upper confidence level of 0.82 pCi/g for soil surrounding the INEEL that is attributed to fallout from aboveground nuclear testing. Radium-226 was detected by gamma spectrometry at all intervals at concentrations slightly elevated above what would be expected naturally. However, the results should be viewed with some caution because of the possible interference with the detection of Ra-226 by gamma spectrometry due to the presence of U-235. Similar to Cs-137, Sr-90 was detected in the 0- to 0.3-m (0- to 1-ft) interval; however, the detected concentration is below the 95% upper confidence level of 0.49 pCi/g for background concentrations. The methyl mercury concentration was below the laboratory method detection limit of 0.005 mg/kg.

C-5.2 Sampling Zone 2

Four coreholes were drilled in Sampling Zone 2, ranging from 3.1 m (10 ft 2 in.) to greater than 3.4 m (11 ft). Three of the four coreholes were drilled to a depth greater than 3.4 m (11 ft); however, samples only were collected from the 0.3-m (1-ft) intervals down to the 3.4-m (11-ft) depth.

- Corehole 2-A-5
  - Depth—>3.4 m (11 ft)
  - Full recovery occurred at all depths
- Corehole 2-B-6
  - Depth—>3.4 m (11 ft)
  - 20 to 25 cm (8 to 10 in.) recovery at most intervals and only 18 cm (7 in.) at the 0.6- to 0.9-m (2- to 3-ft) interval
- Corehole 2-C-7
  - Depth—3.1 m (10 ft 2 in.)
  - No sample was recovered for the 0.9- to 1.2-m (3- to 4-ft) and 3.0- to 3.4-m (10- to 11-ft) intervals
- Corehole 2-D-8
  - Depth—>3.4 m (11 ft)
  - No sample was recovered for the 0.6- to 0.9-m (2- to 3-ft) interval.

Table C-3. Sampling Zone 1 analytical results.

Sample ID:	4P4001		4P4002		4P4003		4P4004		4P4005		4P4006	
Interval (ft):	0–1.0		1.0–2.0		2.0–3.0		3.0–4.0		4.0–5.0		5.0–6.0	
Gamma spectrometry (pCi/g)												
Cs-137	2.05 +/- 0.27 E-01		<0.0730		<0.0809		<0.0809		<0.0559		<0.0959	
Ra-226	2.59 +/- 0.43 E+00		2.82 +/- 0.55 E+00		2.97 +/- 0.45 E+00		2.90 +/- 0.58 E+00		3.43 +/- 0.50 E+00		3.68 +/- 0.63 E+00	
Sr-90 (pCi/g)	1.98 +/- 0.61 E-01		<0.218		<0.206		<0.195		<0.476		<0.422	
Uranium isotope (pCi/g)												
U-234	1.06 +/- 0.08 E+00		9.19 +/- 0.75 E-01		1.04 +/- 0.08 E+00		1.10 +/- 0.09 E+00		1.18 +/- 0.09 E+00		1.44 +/- 0.11 E+00	
U-235	1.03 +/- 0.16 E-01		1.54 +/- 0.21 E-01		1.37 +/- 0.20 E-01		1.37 +/- 0.21 E-01		1.41 +/- 0.20 E-01		2.30 +/- 0.28 E-01	
U-238	1.08 +/- 0.08 E+00		9.95 +/- 0.80 E-01		1.05 +/- 0.08 E+00		1.08 +/- 0.09 E+00		1.14 +/- 0.09 E+00		1.40 +/- 0.11 E+00	
Mercury (mg/kg)	1.9		0.14		0.05		0.08		0.06		0.11	
TCLP metals (µg/L)												
Chromium	3.1	B	1.6	B	12.7		2.2	B	1.7	B	1.3	B
Mercury	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Silver	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U
Methyl mercury (mg/kg)	0.005	U	NA		NA		NA		NA		NA	

Sample ID:	4P4007		4P4008		4P4009		4P4010		4P4011	
Interval (ft):	6.0–7.0		7.0–8.0		8.0–9.0		9.0–10.0		10.0–11.0	
Gamma spectrometry (pCi/g)										
Cs-137	<0.0812		<0.0634		<0.0884		<0.0586		<0.0592	
Ra-226	2.74 +/- 0.58 E+00		2.07 +/- 0.46 E+00		3.25 +/- 0.84 E+00		1.71 +/- 0.42 E+00		1.85 +/- 0.40 E+00	
Sr-90 (pCi/g)	<0.405		<0.420		<0.437		<0.406		<0.425	
Uranium isotope (pCi/g)										
U-234	1.33 +/- 0.10 E+00		1.25 +/- 0.10 E+00		1.07 +/- 0.09 E+00		8.42 +/- 0.70 E-01		8.59 +/- 0.71 E-01	
U-235	2.29 +/- 0.28 E-01		2.29 +/- 0.28 E-01		1.05 +/- 0.17 E-01		9.06 +/- 1.57 E-02		1.68 +/- 0.22 E-01	
U-238	1.18 +/- 0.09 E+00		1.14 +/- 0.09 E+00		1.06 +/- 0.08 E+00		8.42 +/- 0.70 E-01		8.95 +/- 0.74 E-01	
Mercury (mg/kg)	0.02	B	0.03	B	0.02	B	0.02	U	0.02	U
TCLP metals (µg/L)										
Chromium	1.00	B	1.3	B	1.2	B	1.8	B	1.9	B
Mercury	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Silver	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U
Methyl mercury (mg/kg)	NA		NA		NA		NA		NA	

TCLP = toxicity characteristic leaching procedure

The analytical results for Sample Zone 2 are presented in Table C-4. Samples were analyzed for radionuclides (including gamma-emitting isotopes, strontium-90, and uranium isotopes), total mercury, and TCLP metals (including chromium, mercury, and silver). In addition, samples collected from the 0- to 0.3-m (0- to 1-ft) and 0.3- to 0.6-m (1- to 2-ft) intervals also were analyzed for methyl mercury. As can be seen from the data, the only interval for which the mercury concentration exceeded the final remediation goal of 8.4 mg/kg was the 0- to 0.3-m (0- to 1-ft) interval. None of the three metals analyzed by TCLP exceeded the maximum concentrations for the toxicity characteristic, as provided in 40 CFR 261.24. The uranium isotopic concentrations are consistent with those found naturally occurring, with the possible exception of the 1.5- to 1.8-m (5- to 6-ft) interval wherein the concentrations slightly exceeded the 95% upper confidence levels of 1.44 pCi/g and 1.40 pCi/g for U-234 and U-238, respectively. Radium-226 was detected by gamma spectrometry at all intervals, with the exception of the 1.5- to 1.8-m (5- to 6-ft) interval. The concentrations are slightly elevated above what would be expected naturally. However, the results should be viewed with some caution because of the possible interference with the detection of Ra-226 by gamma spectrometry due to the presence of U-235. Strontium-90 was not detected in any of the samples collected. The methyl mercury concentrations in the two samples (one sample and one duplicate) were below the laboratory method detection limit of 0.005 mg/kg.

C-5.3 Sampling Zone 3

Four coreholes were drilled in Sampling Zone 3, ranging from 2.4 m (8 ft) to more than 2.4 m (8 ft). Three of the four coreholes were drilled to a depth greater than 2.4 m (8 ft); however, samples only were collected from the 0.3-m (1-ft) intervals down to the 2.4-m (8-ft) depth.

- Corehole 3-A-9
  - Depth—2.4 m (8 ft)
  - No sample was recovered for the 2.1- to 2.4-m (7- to 8-ft) interval
- Corehole 3-B-10
  - Depth—>2.4 m (8 ft)
  - No samples were recovered for the 1.8- to 2.1-m (6- to 7-ft) and 2.1- to 2.4-m (7- to 8-ft) intervals
- Corehole 3-C-11
  - Depth—>2.4 m (8 ft)
  - No samples were recovered for the 0.3- to 0.6-m (1- to 2-ft), 0.9- to 1.2-m (3- to 4-ft), 1.6- to 1.8-m (5- to 6-ft), and 1.8- to 2.1-m (6- to 7-ft) intervals
- Corehole 3-D-12
  - Depth—>2.4 m (8 ft)
  - No samples were recovered for the 0.9- to 1.2-m (3- to 4-ft), 1.2- to 1.5-m (4- to 5-ft), and 2.1- to 2.4-m (7- to 8-ft) intervals.

Table C-4. Sampling Zone 2 analytical results.

Sample ID:	4P4012		4P4012		4P4013		4P4014		4P4015		4P4016	
Interval (ft):	0–1.0		0–1.0		1.0–2.0		2.0–3.0		3.0–4.0		4.0–5.0	
Gamma spectrometry (pCi/g)												
Ra-226	2.54 +/- 0.48 E+00		1.92 +/- 0.61 E+00		2.49 +/- 0.52 E+00		1.32 +/- 0.38 E+00		2.50 +/- 0.48 E+00		2.22 +/- 0.38 E+00	
Sr-90 (pCi/g)	<0.189		<0.174		<0.184		<0.181		<0.197		<0.209	
Uranium isootope (pCi/g)												
U-234	9.06 +/- 0.73 E-01		8.60 +/- 0.69 E-01		1.01 +/- 0.08 E+00		9.89 +/- 0.78 E-01		1.15 +/- 0.09 E+00		1.23 +/- 0.09 E+00	
U-235	6.80 +/- 1.41 E-02		9.10 +/- 1.50 E-02		6.73 +/- 1.52 E-02		7.76 +/- 1.50 E-02		1.21 +/- 0.18 E-01		1.14 +/- 0.18 E-01	
U-238	1.05 +/- 0.08 E+00		1.05 +/- 0.08 E+00		1.08 +/- 0.09 E+00		1.16 +/- 0.09 E+00		1.23 +/- 0.09 E+00		1.19 +/- 0.09 E+00	
Mercury (mg/kg)	8.8		2.5		2.4		0.90		0.84		0.24	
TCLP metals (µg/L)												
Chromium	0.85	B	0.99	B	1.5	B	2	B	11.8		1.1	B
Mercury	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Silver	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U
Methyl mercury (mg/kg)	0.005	U	0.005	U	NA		NA		NA		NA	

Sample ID:	4P4017		4P4018		4P4019		4P4020		4P4021		4P4022	
Interval (ft):	5.0–6.0		6.0–7.0		7.0–8.0		8.0–9.0		9.0–10.0		10.0–11.0	
Gamma spectrometry (pCi/g)												
Ra-226	<1.40		2.39 +/- 0.46 E+00		2.62 +/- 0.48 E+00		2.67 +/- 0.50 E+00		2.68 +/- 0.50 E+00		1.98 +/- 0.40 E+00	
Sr-90 (pCi/g)	<0.159		<0.190		<0.187		<0.176		<0.194		<0.186	
Uranium isotope (pCi/g)												
U-234	1.56 +/- 0.12 E+00		1.33 +/- 0.10 E+00		1.14 +/- 0.09 E+00		1.16 +/- 0.09 E+00		1.13 +/- 0.09 E+00		1.12 +/- 0.08 E+00	
U-235	1.10 +/- 0.18 E-01		5.36 +/- 1.22 E-02		9.72 +/- 1.77 E-02		8.04 +/- 1.59 E-02		4.91 +/- 1.30 E-02		6.99 +/- 1.32 E-02	
U-238	1.51 +/- 0.11 E+00		1.30 +/- 0.10 E+00		1.26 +/- 0.10 E+00		1.12 +/- 0.09 E+00		1.05 +/- 0.09 E+00		9.91 +/- 0.76 E-01	
Mercury (mg/kg)	0.17		0.05		0.04		0.03	B	0.02	B	0.02	B
TCLP metals (µg/L)												
Chromium	0.80	U	0.80	U	0.82	B	5.2		0.80	U	0.80	U
Mercury	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Silver	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U
Methyl Mercury (mg/kg)	NA		NA		NA		NA		NA		NA	

TCLP = toxicity characteristic leaching procedure

The analytical results for Sample Zone 3 are presented in Table C-5. Samples were analyzed for total mercury and TCLP metals (including chromium, mercury, and silver). As can be seen from the data, none of the mercury concentrations from any of the intervals exceeded the final remediation goal of 8.4 mg/kg. In addition, none of the three metals analyzed by TCLP exceeded the maximum concentrations for the toxicity characteristic, as provided in 40 CFR 261.24.

Table C-5. Sampling Zone 3 analytical results.

Sample ID:	Interval (ft):	Mercury (mg/kg)	TCLP Metals (μg/L)					
			Chromium		Mercury		Silver	
4P402301	0–1.0	2.9	1.6	B	1.0	U	1.8	U
4P402401	1.0–2.0	2.7	3.6	B	1.0	U	1.8	U
4P402501	2.0–3.0	0.21	1.8	B	1.0	U	1.8	U
4P402601	3.0–4.0	0.08	1.7	B	1.0	U	1.8	U
4P402701	4.0–5.0	0.05	1.4	B	1.0	U	1.8	U
4P402801	5.0–6.0	0.04	1.6	B	1.0	U	1.8	U
4P402901	6.0–7.0	0.05	1.4	B	1.0	U	1.8	U
4P403001	7.0–8.0	0.06	2.0	B	1.0	U	1.8	U

TCLP = toxicity characteristic leaching procedure

C-5.4 Sampling Zone 4

Four coreholes were drilled in Sampling Zone 4, ranging from 0.8 m (2.5 ft) to 2.4 m (8 ft). Samples were collected from the 0.3-m (1-ft) intervals down to the 2.4-m (8-ft) depth.

- Corehole 4-A-13
  - Depth—2.4 m (8 ft)
  - Full recovery of all intervals occurred from 0 to 2.1 m (0 to 7 ft) with 75 cm (9 in.) recovered from the 2.1- to 2.4-m (7- to 8-ft) interval
- Corehole 4-B-14
  - Depth—2.4 m (8 ft)
  - Full recovery of all intervals occurred from 0 to 2.4 m (0 to 8 ft)
- Corehole 4-C-15
  - Depth—2.2 m (7 ft 1 in.)
  - Full recovery of all intervals occurred from 0 to 2.1 m (0 to 7 ft)
- Corehole 4-D-16
  - Depth—0.8 m (2.5 ft)
  - Full recovery of all intervals occurred from 0 to 0.8 m (0 to 2.5 ft).

The analytical results for Sample Zone 4 are presented in Table C-6. Samples were analyzed for total mercury and TCLP metals (including chromium, mercury, and silver). As can be seen from the data, none of the mercury concentrations from any of the intervals exceeded the final remediation goal of 8.4 mg/kg. In addition, none of the three metals analyzed by TCLP exceeded the maximum concentrations for the toxicity characteristic, as provided in 40 CFR 261.24.

Table C-6. Sampling Zone 4 analytical results.

Sample ID:	Interval (ft):	Mercury (mg/kg)		TCLP Metals (μg/L)					
				Chromium		Mercury		Silver	
4P403101	0–1.0	2.1		2.3	B	1.2	B	1.8	U
4P403201	1.0–2.0	0.55		1.9	B	1.0	U	1.8	U
4P403301	2.0–3.0	0.08		1.7	B	1.0	U	1.8	U
4P403302	2.0–3.0	0.12		1.8	B	1.0	U	1.8	U
4P403401	3.0–4.0	0.02	U	2.9	B	1.0	U	1.8	U
4P403501	4.0–5.0	0.06		1.6	B	1.0	U	1.8	U
4P403601	5.0–6.0	0.04		1.7	B	1.0	U	1.8	U
4P403701	6.0–7.0	0.07		1.5	B	1.2	B	1.8	U
4P403801	7.0–8.0	0.02	B	2.0	B	1.0	U	1.8	U

TCLP = toxicity characteristic leaching procedure

C-5.5 Sampling Zone 5

Four coreholes were drilled in Sampling Zone 5, ranging from 8 cm (3 in.) to 0.3 m (1 ft). Samples only were collected from the first interval due to low depth to basalt.

- Corehole 5-A
  - Depth—20 cm (8 in.)
  - Recovered only 20 cm (8 in.)
- Corehole 5-B
  - Depth—0.3 m (1 ft)
  - Full recovery occurred for the 0.3-m (1-ft) interval
- Corehole 5-C
  - Depth—0.3 m (1 ft)
  - Full recovery occurred for the 0.3-m (1-ft) interval
- Corehole 5-D
  - Depth—8 cm (3 in.)
  - No sample was recovered for the 8-cm (3-in.) interval.

The analytical results for Sample Zone 5 are presented in Table C-7. Samples were analyzed for radionuclides (including gamma-emitting isotopes, strontium-90, and uranium isotopes), total mercury, and TCLP metals (including chromium, mercury, and silver). As can be seen from the data, mercury concentrations that exceeded the final remediation goal of 8.4 mg/kg are found in the single interval sampled. None of the three metals analyzed by TCLP exceeded the maximum concentrations for the toxicity characteristic, as provided in 40 CFR 261.24. Concentrations of uranium isotopes in the interval exceeded the naturally occurring background levels. Cesium-137 was found in this interval; however, its concentration is less than the 95% upper confidence level of 0.82 pCi/g found in soil surrounding the INEEL that is attributed to fallout from atmospheric nuclear testing. The concentration of Ra-226 was elevated in the duplicate sample above naturally occurring levels, but was below the minimum detectable activity in the sample. Strontium-90 was not detected in either the sample or its duplicate.

Table C-7. Sampling Zone 5 analytical results.

Sample ID:	4P404001		4P404002	
Interval (ft):	0–1.0		0–1.0	
Gamma spectrometry (pCi/g)				
Cs-137	3.88 +/- 0.50 E-01		3.60 +/- 0.40 E-01	
Ra-226	<1.64		4.93 +/- 0.61 E+00	
Sr-90 (pCi/g)	<0.326		<0.332	
Uranium isotope (pCi/g)				
U-234	4.11 +/- 0.33 E+00		4.49 +/- 0.35 E+00	
U-235	6.88 +/- 0.74 E-01		4.73 +/- 0.55 E-01	
U-238	5.53 +/- 0.43 E+00		6.35 +/- 0.48 E+00	
Mercury (mg/kg)	63.0		56.4	
TCLP metals (µg/L)				
Chromium	1.7	B	1.2	B
Mercury	11.9		6.9	
Silver	1.8	U	1.8	U

TCLP = toxicity characteristic leaching procedure

C-5.6 Sampling Zone 6

Four coreholes were drilled in Sampling Zone 6, ranging from 0.3 m (1 ft) to 1.8 m (6 ft). Samples were collected from the 0.3-m (1-ft) intervals down to the 1.8-m (6-ft) depth.

- Corehole 6-A-21
  - Depth—0.3 m (1 ft)
  - Full recovery occurred for the 0.3-m (1-ft) interval
- Corehole 6-B-22
  - Depth—1.8 m (6 ft)
  - Full recovery occurred at all depths
- Corehole 6-C-23
  - Depth—76 cm (2 ft 6 in.)

- Full recovery occurred for the first two intervals with 13 cm (5 in.) recovered from the 0.6- to 0.9-m (2- to 3-ft) interval

- Corehole 6-D-24
  - Depth—84 cm (2 ft 9 in.)
  - Full recovery of all intervals occurred down to 84 cm (2 ft 9 in.).

The analytical results for Sample Zone 6 are presented in Table C-8. Samples were analyzed for radionuclides (including gamma-emitting isotopes, strontium-90, and uranium isotopes), total mercury, and TCLP metals (including chromium, mercury, and silver). One sample collected from the 0- to 0.3-m (0- to 1-ft) interval was analyzed for methyl mercury. As can be seen from the data, mercury concentrations that exceeded the final remediation goal of 8.4 mg/kg were found in all six depth intervals from 0 to 1.8 m (0 to 6 ft). None of the three metals analyzed by TCLP exceeded the maximum concentrations for the toxicity characteristic, as provided in 40 CFR 261.24. Concentrations of uranium isotopes in the first and third intervals (0 to 0.3 m [0 to 1 ft] and 0.6 to 0.9 m [2 to 3 ft], respectively) exceeded the naturally occurring background levels. Cesium-137 was found in the first depth interval from 0 to 0.3 m (0 to 1 ft); however, its concentration is less than the 95% upper confidence level of 0.82 pCi/g found in soil surrounding the INEEL that is attributed to fallout from atmospheric nuclear testing. The Ra-226 concentrations were elevated in five of the six intervals above naturally occurring levels, with the exception being the 0.6- to 0.9-m (2- to 3-ft) interval. Strontium-90 was not detected in samples collected from any of the six depth intervals. The methyl mercury concentration was below the laboratory method detection limit of 0.005 mg/kg.

C-5.7 Sampling Zone 7

Four coreholes were drilled in Sampling Zone 7, ranging from 46 cm (1 ft 6 in.) to greater than 3.6 m (12 ft). Samples were collected from the 0.3-m (1-ft) intervals down to the 1.5-m (5-ft) depth.

- Corehole 7-A-25
  - Depth—46 cm (1 ft 6 in.)
  - Recovered 36 cm (14 in.) of sediment

- Corehole 7-B-27
  - Depth—1.1 m (3 ft 6 in.)
  - No sample was recovered for the 0.3- to 0.6-m (1- to 2-ft) interval and only 15 cm (6 in.) was recovered from the 0.9- to 1.1-m (3- to 3-ft 6-in.) interval

- Corehole 7-C-29
  - Depth—1.5 m (5 ft)
  - Full recovery occurred at all depths

- Corehole 7-D-31
  - Depth—>3.6 m (12 ft)
  - Full recovery occurred at all depths.

Table C-8. Sampling Zone 6 analytical results.

Sample ID:	4P4047		4P4048		4P4049		4P4050		4P4051		4P4052	
Interval (ft):	0–1.0		1.0–2.0		2.0–3.0		3.0–4.0		4.0–5.0		5.0–6.0	
Gamma spectrometry (pCi/g)												
Cs-137	2.45 +/- 0.41 E-01		<0.0985		<0.0812		<0.0967		<0.0660		<0.0724	
Ra-226	3.98 +/- 0.68 E+00		2.45 +/- 0.51 E+00		<1.70		2.99 +/- 0.68 E+00		2.20 +/- 0.50 E+00		1.90 +/- 0.45 E+00	
U-235	<0.409		<0.379		4.88 +/- 1.04 E-01		<0.490		<0.398		<0.239	
Sr-90 (pCi/g)	<0.361		<0.343		<0.384		<0.356		<0.353		<0.350	
Uranium isotope (pCi/g)												
U-234	2.20 +/- 0.19 E+00		1.16 +/- 0.11 E+00		9.72 +/- 0.74 E+00		1.09 +/- 0.10 E+00		1.25 +/- 0.12 E+00		1.03 +/- 0.10 E+00	
U-235	1.76 +/- 0.31 E-01		1.19 +/- 0.24 E-01		1.13 +/- 0.11 E+00		1.30 +/- 0.25 E-01		1.20 +/- 0.25 E-01		9.91 +/- 2.12 E-02	
U-238	3.16 +/- 0.26 E+00		1.41 +/- 0.13 E+00		1.38 +/- 0.10 E+01		1.35 +/- 0.12 E+00		1.33 +/- 0.12 E+00		1.11 +/- 0.10 E+00	
Mercury (mg/kg)	57.3		75.8		82.8		54.7		42.7		47.0	
TCLP metals (µg/L)												
Chromium	1.6	B	1.6	B	1.3	B	1.8	B	2.6	B	2.1	B
Mercury	1.3	B	32.4		7.6		78.2		75.4		56.0	
Silver	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U
Methyl mercury (mg/kg) 0.005		U	NA		NA		NA		NA		NA	

TCLP = toxicity characteristic leaching procedure

The analytical results for Sample Zone 7 are presented in Table C-9. Samples were analyzed for radionuclides (including gamma-emitting isotopes, strontium-90, and uranium isotopes), total mercury, and TCLP metals (including chromium, mercury, and silver). Three samples collected from the 0- to 0.3-m (0- to 1-ft), 0.3- to 0.6-m (1- to 2-ft), and 0.9- to 1.2-m (3- to 4-ft) intervals also were analyzed for methyl mercury. As can be seen from the data, mercury concentrations that exceeded the final remediation goal of 8.4 mg/kg were found in all five depth intervals from 0 to 1.5 m (0 to 5 ft). None of the three metals analyzed by TCLP exceeded the maximum concentrations for the toxicity characteristic, as provided in 40 CFR 261.24. Concentrations of uranium isotopes in the first three intervals from 0 to 0.9 m (0 to 3 ft) exceeded the naturally occurring background levels with the uranium isotopic concentration for the fourth interval from 0.9 to 1.2 m (3 to 4 ft) slightly elevated above the 95% upper confidence limit for soil at the INEEL. Cesium-137 was present in soil from the first two intervals (0 to 0.6 m [0 to 2 ft]); however, the concentrations were less than the 95% upper confidence level of 0.82 for soil surrounding the INEEL. The concentration of Ra-226 was elevated in the 0.9- to 1.5-m (3- to 5-ft) intervals above naturally occurring levels. Also, Nb-95 was detected in one sample collected from the 0.6- to 0.9-m (2- to 3-ft) interval; however, this result is questionable given that no Cs-137 was detected in this interval as would be expected in the presence of Nb-95, and Nb-95's half-life is only 35 days. Furthermore, the isotope was not detected in the field duplicate sample. No Sr-90 was detected at any of the intervals. The methyl mercury concentrations in the three samples collected were below the laboratory method detection limit of 0.005 mg/kg.

C-5.8 Sampling Zone 8

Four coreholes were drilled in Sampling Zone 8, ranging from 0.6 m (2 ft) to 1.4 m (4 ft 6 in.). Samples were collected from the 0.3-m (1-ft) intervals down to the 1.4-m (4-ft 6-in.) depth.

- Corehole 8-C-30
  - Depth—1.1 m (3 ft 6 in.)
  - Full recovery occurred at all depths
- Corehole 8-B-28
  - Depth—1.2 m (4 ft)
  - Full recovery occurred at all depths
- Corehole 8-A-26
  - Depth—0.6 m (2 ft)
  - Full recovery occurred at all depths
- Corehole 8-D-32
  - Depth—1.4 m (4 ft 6 in.)
  - Full recovery occurred at all depths including 15 cm (6 in.) of the 1.2- to 1.4-m (4- to 4-ft 6-in.) interval.

Table C-9. Sampling Zone 7 analytical results.

Sample ID:	4P405301		4P405401		4P405501		4P405502		4P405601		4P405701	
Interval (ft):	0–1.0		1.0–2.0		2.0–3.0		2.0–3.0		3.0–4.0		4.0–5.0	
Gamma spectrometry (pCi/g)												
Cs-137	5.01 +/- 0.50 E-01		9.62 +/- 2.34 E-02		<0.0569		<0.0970		<0.0916		<0.0940	
Nb-95	<0.0475		0.0878		1.19 +/- 0.29 E-01		<0.101		<0.101		<0.133	
Ra-226	<1.31		<1.73		<1.33		<1.75		2.85 +/- 0.60 E+00		3.29 +/- 0.61 E+00	
U-235	<0.387		6.56 +/- 1.15 E-01		4.03 +/- 0.88 E-01		8.53 +/- 1.85 E-01		<0.404		<0.486	
Sr-90 (pCi/g)	<0.432		<0.370		<0.372		<0.307		<0.349		<0.332	
Uranium isotope (pCi/g)												
U-234	4.77 +/- 0.37 E+00		1.13 +/- 0.09 E+01		1.44 +/- 0.11 E+01		1.21 +/- 0.09 E+01		1.51 +/- 0.13 E+00		9.11 +/- 0.90 E-01	
U-235	4.39 +/- 0.52 E-01		1.21 +/- 0.12 E+00		1.34 +/- 0.13 E+00		1.10 +/- 0.11 E+00		1.48 +/- 0.27 E-01		9.14 +/- 2.07 E-02	
U-238	8.80 +/- 0.66 E+00		1.89 +/- 0.14 E+01		2.30 +/- 0.18 E+01		2.05 +/- 0.15 E+01		2.15 +/- 0.18 E+00		1.15 +/- 0.11 E+00	
Mercury (mg/kg)	85.3		45.5		68.4		67.7		118		44.2	
TCLP metals (µg/L)												
Chromium	1.9	B	2.3	B	2.6	B	3.1	B	1.2	B	1.0	B
Mercury	5.3		39.9		14.2		117.0		117.0		148.0	
Silver	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U
Methyl mercury (mg/kg)	0.005	U	0.005	U	NA		NA		0.005U		NA	

TCLP = toxicity characteristic leaching procedure

The analytical results for Sample Zone 8 are presented in Table C-10. Samples were analyzed for radionuclides (including gamma-emitting isotopes, strontium-90, and uranium isotopes), total mercury, and TCLP metals (including chromium, mercury, and silver). Three samples collected from the 0- to 0.3-m (0- to 1-ft), 0.3- to 0.6-m (1- to 2-ft), and 0.6- to 0.9-m (2- to 3-ft) intervals also were analyzed for methyl mercury. As can be seen from the data, mercury concentrations that exceeded the final remediation goal of 8.4 mg/kg are found in all four depth intervals from 0 to 1.2 m (0 to 4 ft). None of the three metals analyzed by TCLP exceeded the maximum concentrations for the toxicity characteristic, as provided in 40 CFR 261.24. Concentrations of uranium isotopes in the first three intervals from 0 to 0.9 m (0 to 3 ft) exceeded the naturally occurring background levels. Cesium-137 was found in the first depth interval from 0 to 0.3 m (0 to 1 ft); however, its concentration is less than the 95% upper confidence level of 0.82 pCi/g found in soil surrounding the INEEL that is attributed to fallout from atmospheric nuclear testing. The concentration of Ra-226 was elevated in the 0.6- to 0.9-m (2- to 3-ft) interval above naturally occurring levels. In addition, Sr-90 was detected in samples collected from both the 0.6- to 0.9-m (2- to 3-ft) and 0.9- to 1.2-m (3- to 4-ft) intervals. The methyl mercury concentrations in the three samples collected were below the laboratory method detection limit of 0.005 mg/kg.

Table C-10. Sampling Zone 8 analytical results.

Sample ID:	4P405901		4P406001		4P406101		4P406201	
Interval (ft):	0–1.0		1.0–2.0		2.0–3.0		3.0–4.0	
Gamma Spectrometry (pCi/g)								
Cs-137	1.01 +/- 0.24 E-01		<0.0883		<0.0584		<0.0924	
Ra-226	<11.9		<1.60		6.34 +/- 0.72 E+00		<1.71	
U-235	4.14 +/- 1.08 E-01		6.22 +/- 1.47 E-01		<0.257		<0.350	
Sr-90 (pCi/g)	<0.335		<0.337		4.53 +/- 0.73 E-01		3.63 +/- 0.75 E-01	
Uranium Isotope (pCi/g)								
U-234	9.22 +/- 0.60 E+00		4.88 +/- 0.31 E+00		8.79 +/- 0.56 E+00		1.09 +/- 0.07 E+01	
U-235	9.11 +/- 0.74 E-01		5.46 +/- 0.45 E-01		7.30 +/- 0.59 E-01		1.07 +/- 0.09 E+01	
U-238	1.68 +/- 0.11 E+01		8.88 +/- 0.56 E+00		1.54 +/- 0.10 E+01		2.19 +/- 0.14 E+01	
Mercury (mg/kg)	90.3		60.6		60.6		126	
TCLP Metals (µg/L)								
Chromium	1.7	B	2.8	B	7.1		1.1	B
Mercury	2.9		13.2		6.7		27.7	
Silver	1.8	U	1.8	U	1.8	U	1.8	U
Methyl Mercury (mg/kg)	0.005	U	0.005	U	0.005	U	NA	

TCLP = toxicity characteristic leaching procedure

C-5.9 Sampling Zone 9

Four coreholes were drilled in Sampling Zone 9, ranging from 0.76 m (2 ft 6 in.) to 1.8 m (6 ft). Samples were collected from the 0.3-m (1-ft) intervals down to the 1.8-m (6-ft) depth. (Some recoveries were more than the depths that were cored, because dirt falls in from the sides as the samples are taken.)

- Corehole 9-B-35
  - Depth—0.76 m (2 ft 6 in.)
  - Full recovery occurred at all depths including 15 cm (6 in.) of the 0.6- to 0.76-m (2- to 2-ft 6-in.) interval
- Corehole 9-C-33
  - Depth—1.75 m (5 ft 9 in.)
  - Full recovery occurred at all depths including 25 cm (10 in.) at the 1.5- to 1.75-m (5- to 5-ft 9-in.) interval
- Corehole 9-A-37
  - Depth—1.65 m (5 ft 6 in.)
  - Full recovery occurred at all depths including a 20-cm (8-in.) recovery at the 1.5- to 1.65-m (5- to 5-ft 6-in.) interval
- Corehole 9-D-39
  - Depth—1.8 m (6 ft)
  - Full recovery occurred at all depths.

The analytical results for Sample Zone 9 are presented in Table C-11. Samples were analyzed for total mercury and TCLP metals, including chromium, mercury, and silver. As can be seen from the data, none of the mercury concentrations exceeded the final remediation goal of 8.4 mg/kg. In addition, none of the three metals analyzed by TCLP exceeded the maximum concentrations for the toxicity characteristic, as provided in 40 CFR 261.24.

Table C-11. Sampling Zone 9 analytical results.

Sample ID	Interval (ft)	Mercury (mg/kg)	TCLP Metals (μg/L)					
			Chromium		Mercury		Silver	
4P406501	0–1.0	4.5	1.8	B	1.0	U	1.8	U
4P406601	1.0–2.0	1.7	3.1	B	1.0	U	1.8	U
4P406701	2.0–3.0	0.21	2.1	B	1.0	U	1.8	U
4P406018	3.0–4.0	0.13	2.5	B	1.0	U	1.8	U
4P406901	4.0–5.0	0.09	2.3	B	1.0	U	1.8	U
4P407001	5.0–6.0	0.06	1.7	B	1.0	U	1.8	U

TCLP = toxicity characteristic leaching procedure

C-5.10 Sampling Zone 10

Four coreholes were drilled in Sampling Zone 10, ranging from 2.5 cm (1 in.) to 0.6 m (2 ft). Samples were collected from the 0.3-m (1-ft) intervals down to the 0.6-m (2-ft) depth.

- Corehole 10-A
  - Depth—2.5 cm (1 in.)
  - No recovery because at basalt
- Corehole 10-B
  - Depth—0.3 m (1 ft)
  - Recovered 25 cm (10 in.) from the 0.3-m (1-ft) interval
- Corehole 10-C
  - Depth—0.3 m (1 ft)
  - Recovered 15 cm (6 in.) from the 0.3-m (1-ft) interval
- Corehole 10-D
  - Depth—0.6 m (2 ft)
  - Full recovery occurred at all depths.

The analytical results for Sample Zone 10 are presented in Table C-12. Samples were analyzed for total mercury and TCLP metals, including chromium, mercury, and silver. As can be seen from the data, none of the mercury concentrations exceeded the final remediation goal of 8.4 mg/kg. In addition, none of the three metals analyzed by TCLP exceeded the maximum concentrations for the toxicity characteristic, as provided in 40 CFR 261.24.

Table C-12. Sampling Zone 10 analytical results.

Sample ID	Interval (ft)	Mercury (mg/kg)	TCLP Metals (µg/L)					
			Chromium		Mercury		Silver	
4P407201	0–1.0	4.5	1.6	B	1.0	U	1.8	U
4P407301	1.0-2.0	2.5	3.4	B	1.0	U	1.8	U
4P407302	1.0-2.0	0.97	2.7	B	1.0	U	1.8	U

TCLP = toxicity characteristic leaching procedure

C-5.11 Sampling Zone 11

Four coreholes were drilled in Sampling Zone 11, ranging from 15 cm (6 in.) to 1.8 m (6 ft). Samples only were collected from the 0.3-m (1-ft) intervals down to the 1.8-m (6-ft) depth.

- Corehole 11-A-41
  - Depth—15 cm (6 in.)
  - Recovered 15 cm (6 in.) using hand auger
- Corehole 11-B-42
  - Depth—0.6 m (2 ft)
  - No sample was recovered for the 0.3- to 0.6-m (1- to 2-ft) interval
- Corehole 11-C-43
  - Depth—1.8 m (6 ft)
  - Full recovery occurred at all depths
- Corehole 11-D-44
  - Depth—1.8 m (6 ft)
  - Full recovery occurred at all depths.

The analytical results for Sample Zone 11 are presented in Table C-13. Samples were analyzed for total mercury and TCLP metals, including chromium, mercury, and silver. As can be seen from the data, mercury concentrations that exceeded the final remediation goal of 8.4 mg/kg are present in the second and third intervals from 0.3 to 0.9 m (1 to 3 ft). None of the three metals analyzed by TCLP exceeded the maximum concentrations for the toxicity characteristic, as provided in 40 CFR 261.24.

Table C-13. Sampling Zone 11 analytical results.

Sample ID	Interval (ft)	Mercury (mg/kg)	TCLP Metals (µg/L)					
			Chromium		Mercury		Silver	
4P408001	0–1.0	5.2	1.5	B	1.0	U	1.8	U
4P408101	1.0–2.0	15.0	0.80	U	1.0	U	1.8	U
4P408201	2.0–3.0	19.2	0.80	U	1.0	U	1.8	U
4P408301	3.0–4.0	2.2	0.80	U	1.0	U	1.8	U
4P408401	4.0–5.0	1.0	0.80	U	1.0	U	1.8	U
4P408501	5.0–6.0	2.2	0.80	U	1.0	U	1.8	U

TCLP = toxicity characteristic leaching procedure

C-5.12 Sampling Zone 12

Four coreholes were drilled in Sampling Zone 12, ranging from 1.8 m (6 ft) to greater than 2.7 m (9 ft). One of the four coreholes was drilled to a depth greater than 2.7 m (9 ft); however, samples only were collected from the 0.3-m (1-ft) intervals down to the 2.7-m (9-ft) depth.

- Corehole 12-A-25
  - Depth—1.8 m (6 ft)
  - Full recovery occurred at all depths
- Corehole 12-B-47
  - Depth—> 2.7 m (9 ft)
  - Full recovery occurred up to 2.7 m (9 ft)
- Corehole 12-C-51
  - Depth—1.9 m (6 ft 3 in.)
  - Full recovery occurred at all depths
- Corehole 12-D-53
  - Depth—2.3 m (7 ft 7 in.)
  - Full recovery occurred at all depths.

The analytical results for Sample Zone 12 are presented in Table C-14. Samples were analyzed for total mercury and TCLP metals, including chromium, mercury, and silver. As can be seen from the data, mercury concentrations that exceeded the final remediation goal of 8.4 mg/kg are present in the first two intervals down to 0.6 m (2 ft). None of the three metals analyzed by TCLP exceeded the maximum concentrations for the toxicity characteristic, as provided in 40 CFR 261.24.

Table C-14. Sampling Zone 12 analytical results.

Sample ID	Interval (ft)	Mercury (mg/kg)	TCLP Metals (µg/L)					
			Chromium		Mercury		Silver	
4P408601	0–1.0	9.2	1.1	B	1.0	U	1.8	U
4P408701	1.0–2.0	13.3	2.0	B	1.0	U	1.8	U
4P408801	2.0–3.0	2.2	1.8	B	1.2	B	1.8	U
4P408901	3.0–4.0	1.9	1.3	B	1.3	B	1.8	U
4P409001	4.0–5.0	1.3	0.80	U	1.0	U	1.8	U
4P409101	5.0–6.0	1.9	1.6	B	1.0	U	1.8	U
4P409201	6.0–7.0	2.5	2.5	B	2.5		1.8	U
4P409301	7.0–8.0	1.1	1.7	B	1.0	U	1.8	U
4P409401	8.0–9.0	1.7	2.6	B	3.7		1.8	U

TCLP = toxicity characteristic leaching procedure

C-5.13 Sampling Zone 13

Four coreholes were drilled in Sampling Zone 13, ranging from 0.76 m (2 ft 6 in.) to greater than 2.4 m (8 ft). One of the four coreholes was drilled to a depth greater than 2.4 m (8 ft); however, samples only were collected from the 0.3-m (1-ft) intervals down to the 2.4-m (8-ft) depth.

- Corehole 13-A-46
  - Depth—1.2 m (4 ft)
  - Full recovery occurred at all depths
- Corehole 13-B-48
  - Depth—0.9 m (3 ft)
  - Full recovery occurred at all depths
- Corehole 13-C-54
  - Depth—0.76 m (2 ft 6 in.)
  - Full recovery occurred at all depths
- Corehole 13-D-52
  - Depth—>2.4 m (8 ft)
  - Full recovery occurred at all depths down to 2.4 m (8 ft).

The analytical results for Sample Zone 13 are presented in Table C-15. Samples were analyzed for total mercury and TCLP metals, including chromium, mercury, and silver. As can be seen from the data, mercury concentrations that exceeded the final remediation goal of 8.4 mg/kg are present in the first three intervals down to 0.9 m (3 ft). None of the three metals analyzed by TCLP exceeded the maximum concentrations for the toxicity characteristic, as provided in 40 CFR 261.24.

Table C-15. Sampling Zone 13 analytical results.

Sample ID	Interval (ft)	Mercury (mg/kg)	TCLP Metals (µg/L)					
			Chromium		Mercury		Silver	
4P409501	0–1.0	22.4	1.5	B	1.0	U	1.8	U
4P409502	0–1.0	34.4	1.2	B	1.0	U	1.8	U
4P409601	1.0–2.0	10.4	1.2	B	1.0	U	1.8	U
4P409701	2.0–3.0	2.0	1.3	B	1.0	U	1.8	U
4P409801	3.0–4.0	0.76	1.1	B	1.0	U	1.8	U
4P409901	4.0–5.0	0.08	2.6	B	1.0	U	1.8	U
4P410001	5.0–6.0	0.07	1.6	B	1.0	U	1.8	U
4P410101	6.0–7.0	0.04	3.3	B	1.0	U	1.8	U
4P410201	7.0–8.0	0.05	3.0	B	1.0	U	1.8	U

TCLP = toxicity characteristic leaching procedure

C-5.14 Sampling Zone 14

Four coreholes were drilled in Sampling Zone 14, ranging from 1.1 m (3 ft 6 in.) to greater than 2.4 m (8 ft). One of the four coreholes was drilled to a depth greater than 2.4 m (8 ft); however, samples only were collected from the 0.3-m (1-ft) intervals down to the 2.4-m (8-ft) depth.

- Corehole 14-A-50
  - Depth—2.0 m (6 ft 6 in.)
  - Full recovery occurred at all depths
- Corehole 14-B-55
  - Depth—1.1 m (3 ft 6 in.)
  - Full recovery occurred at all depths down to 0.9 m (3 ft)—no recovery for the 0.9- to 1.1-m (3- to 3-ft 6-in.) interval
- Corehole 14-C-56
  - Depth—1.85 m (6 ft 1 in.)
  - Full recovery occurred at all depths down to 1.8 m (6 ft)
- Corehole 14-D-49
  - Depth—>2.4 m (8 ft)
  - Full recovery occurred at all depths down to 2.4 m (8 ft).

The analytical results for Sample Zone 14 are presented in Table C-16. Samples were analyzed for total mercury and TCLP metals, including chromium, mercury, and silver. As can be seen from the data, mercury concentrations that exceeded the final remediation goal of 8.4 mg/kg are present in the first two intervals down to 0.6 m (2 ft) and then again at the 1.2- to 1.5-m (4- to 5-ft) interval. None of the three metals analyzed by TCLP exceeded the maximum concentrations for the toxicity characteristic, as provided in 40 CFR 261.24.

Table C-16. Sampling Zone 14 analytical results.

Sample ID	Interval (ft)	Mercury (mg/kg)	TCLP Metals (µg/L)					
			Chromium		Mercury		Silver	
4P410301	0–1.0	41.4	1.4	B	7.1		1.8	U
4P410401	1.0–2.0	40.0	0.9	B	3.3		1.8	U
4P410501	2.0–3.0	5.1	1.1	B	1.0	U	1.8	U
4P410601	3.0–4.0	2.7	0.8	U	1.2	B	1.8	U
4P410701	4.0–5.0	12.1	2.7	B	14.9		1.8	U
4P410801	5.0–6.0	1.3	3.7	B	4.0		1.8	U
4P410901	6.0–7.0	2.2	4.6	B	1.6	B	1.8	U
4P411001	7.0–8.0	0.03	2.8	B	3.3		1.8	U

TCLP = toxicity characteristic leaching procedure

C-5.15 Sampling Zone 15

Four coreholes were drilled in Sampling Zone 15, ranging from 1.5 m (5 ft) to 2.0 m (6 ft 6 in.). Samples were collected from the 0.3-m (1.0-ft) intervals down to the 2.0-m (6-ft 6-in.) depth.

- Corehole 15-A
  - Depth—1.5 m (5 ft)
  - Full recovery occurred at all depths
- Corehole 15-B
  - Depth—2.0 m (6 ft 6 in.)
  - Full recovery occurred at all depths
- Corehole 15-C
  - Depth—2.0 m (6 ft 6 in.)
  - Full recovery occurred at all depths
- Corehole 15-D
  - Depth—1.7 m (5 ft 6 in.)
  - Full recovery occurred at all depths.

The analytical results for Sample Zone 15 are presented in Table C-17. Samples were analyzed for total mercury and TCLP metals, including chromium, mercury, and silver. As can be seen from the data, none of the mercury concentrations exceeded the final remediation goal of 8.4 mg/kg. In addition, none of the three metals analyzed by TCLP exceeded the maximum concentrations for the toxicity characteristic, as provided in 40 CFR 261.24.

Table C-17. Sampling Zone 15 analytical results.

Sample ID	Interval (ft)	Mercury (mg/kg)	TCLP Metals (µg/L)					
			Chromium		Mercury		Silver	
4P412001	0–1.0	0.18	0.80	U	1.0	U	1.8	U
4P412101	1.0–2.0	0.09	1.9	B	1.0	U	1.8	U
4P412201	2.0–3.0	0.07	1.2	B	1.0	U	1.8	U
4P412301	3.0–4.0	0.29	1.9	B	1.0	U	1.8	U
4P412401	4.0–5.0	1.8	2.5	B	1.0	U	1.8	U
4P412501	5.0–6.0	0.05	1.4	B	1.0	U	1.8	U
4P412601	6.0–7.0	0.05	2.0	B	1.0	U	1.8	U

TCLP = toxicity characteristic leaching procedure

C-5.16 Miscellaneous Sampling

A total of four core samples were collected from the basalt, including two from within Sampling Zone 6 and two from within Zone 7. These samples were analyzed for total mercury. The results are summarized in Table C-18. Mercury concentrations in one of the four basalt samples exceeded the final remediation goal of 8.4 mg/kg. These samples were re-analyzed after brushing off any residual soil on the basalt. The mercury concentrations were all lower than the final remediation goal in this re-analysis.

Table C-18. Basalt core analytical results.

Sample ID	Core	Recovery	Interval (ft):	Mercury Concentration (mg/kg)	Re-analyzed Mercury Concentration (mg/kg)
4P411301	6-1	10 cm (4 in.)	6.0–6.25	119	5.4
4P411401	6-2	20 cm (8 in.)	6.0–6.25	3.4	2.9
4P411501	7-1	23 cm (9 in.)	6.0–6.25	0.3	0.3
4P411601	7-1	18 cm (7 in.)	6.0–6.25	6.5	2.4

In addition, samples were collected (Table C-19) from a large and a small soil pile (Sample Numbers 4P411701 and 4P411801, respectively), sediment lying between Zones 2 and 6 (4P413201), the surface of the inlet trench (4P413301), and surface soil immediately northeast of Zone 13 (4P413401). These samples were analyzed for total mercury and TCLP metals, including chromium, mercury, and silver. The mercury concentrations for the samples collected from the large soil pile, the sediment lying between Zones 2 and 6, the surface of the inlet trench, and the surface soils immediately northeast of Zone 13 exceeded the final remediation goal of 8.4 mg/kg. None of the three metals analyzed by TCLP exceeded the maximum concentrations for the toxicity characteristic, as provided in 40 CFR 261.24.

Table C-19. Analytical results for miscellaneous samples.

Sample ID:	Mercury (mg/kg)	TCLP Metals (µg/L)					
		Chromium		Mercury		Silver	
4P4117	16.2	1.2	B	1.0	U	1.8	U
4P4118	0.62	0.80	U	1.1	B	1.8	U
4P4132	90.5	0.80	U	11.0		1.8	U
4P4133	78.5	1.1	B	1.0	U	1.8	U
4P4134	43.5	1.4	B	1.0	U	1.8	U

TCLP = toxicity characteristic leaching procedure

C-6. MERCURY SUMMARY

Table C-20 summarizes the mercury concentrations by interval within zone. This provides a description of the vertical and horizontal extent of contamination across the CFA-04 site. Mercury concentrations generally are lower than were obtained during previous sampling (DOE-ID 2002a). Previous sampling was done in 6-in. intervals, whereas this sampling was done in 12-in. intervals that were then composited for a zone. In accordance with the preremediation sampling plan, the data in Table C-20 are to be used to determine where excavation will occur. Although the concentrations generally are lower, the same areas that would have been excavated in accordance with previous sampling are to be excavated in accordance with this sampling. The difference is that this sampling indicates that the waste stream as a whole has a lower mercury concentration. Although TCLP mercury was not found during this sampling, the area within Zones 6 and 7 where previous TCLP mercury was found should be treated as though it exceeds TCLP mercury for waste disposition purposes. It also should be noted for waste disposition purposes that TCLP chromium and silver were not exceeded.

Table C-20. Summary of mercury concentrations in mg/kg.

	Sampling Interval (ft)								
Zone	0–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9
1	1.9	0.14	0.05	0.08	0.06	0.11	—	—	—
2	8.8/2.5	2.4	0.90	0.84	0.24	—	—	—	—
3	2.9	2.7	0.21	0.08	0.05	0.04	0.05	0.06	—
4	2.1	0.55	0.08/0.12	0.02	0.06	0.04	0.07	0.02	—
5	63.0/56.4	—	—	—	—	—	—	—	—
6	57.3	75.8	82.8	54.7	42.7	47.0	—	—	—
7	85.3	45.5	68.4/67.7	118	44.2	—	—	—	—
8	90.3	60.6	60.6	126	—	—	—	—	—
9	4.5	1.7	0.21	0.13	0.09	0.06	—	—	—
10	4.5	2.5/0.97	—	—	—	—	—	—	—
11	5.2	15.0	19.2	2.2	1.0	2.2	—	—	—
12	9.2	13.3	2.2	1.9	1.3	1.9	2.5	1.1	1.7
13	22.4/34.4	10.4	2.0	0.76	0.08	0.07	0.04	0.05	—
14	41.4	40.0	5.1	2.7	12.1	1.3	2.2	0.03	—
15	0.18	0.09	0.07	0.29	1.8	0.05	0.05	—	—

Note: For those intervals within a zone where two mercury concentrations are provided, one value is for the sample and the other is for a field duplicate.

Table C-21 summarizes the methyl mercury concentrations and compares the results to the total mercury concentrations for the same location.

Table C-21. Summary and comparison of methyl mercury and mercury concentrations.

Zone	Sampling Interval (ft)	Reported Methyl Mercury Concentration (mg/kg) (0.005 is the detection limit.)	Adjusted Percent Methyl Mercury Concentration (Reported concentration is scaled up for low matrix spike recovery.)	Mercury (mg/kg)	Percent Methyl Mercury (compared to the detection limit, if below)	Percent Methyl Mercury (compared to reported concentration)	Percent Methyl Mercury (compared to adjusted concentration)
1	0–1	0.00032 (U)	0.00055	1.9	0.3	0.02	0.03
2	0–1	0.00139 (U)	0.00238	8.8	0.06	0.02	0.03
2	0–1 (Duplicate)	0.00240 (U)	0.00410	2.5	0.2	0.1	0.2
6	0–1	0.00139 (U)	0.00238	57.3	0.009	0.002	0.004
7	0–1	0.00655 (J)	0.01120	85.3	0.008	0.008	0.01
7	1–2	0.00135 (U)	0.00231	45.5	0.01	0.003	0.005
7	3–4	0.00246 (U)	0.00421	118	0.004	0.002	0.004
8	0–1	0.00098 (U)	0.00168	90.3	0.006	0.001	0.002
8	1–2	0.00353 (U)	0.00603	60.6	0.008	0.006	0.01
8	2–3	0.00137 (U)	0.00234	60.6	0.008	0.002	0.004

Methyl mercury was only detected in one of the samples. This concentration is 0.008 % of the total mercury detected. This result validates the assumption used in the *Re-evaluation of the Final Remediation Goals for Mercury at the CFA-04 (CFA-674 Pond)* (INEEL 2002) by being below the conservative percentage of 0.5% methyl mercury and demonstrates that the 8.4-mg/kg final remediation goal is acceptable.

The analytical technique used for these analyses was determined to be acceptable despite being outside the 28-day hold time (31 to 40 days) and having a slightly low matrix spike recovery (55.2% and 61.6% with an average recovery of 58.5%). The hold time was exceeded because of the extra work that had to be done to modify the method. The samples were kept at 4°C, which should have prevented any loss of mercury. The low matrix spike recoveries are not surprising since the matrix is soil. The percent recoveries obtained for the aqueous laboratory continuing calibration verification samples were good (with 80–120%). The laboratory control samples that were run on a solid matrix also had good recoveries (86.3% and 100%). The high recoveries on the solid matrix control samples demonstrate the proficiency of the complete analytical system utilized. This includes the chemist, the preparatory technique, and the determinative EPA Method 1630 (see footnote a).

Even with an adjustment for the low matrix spike recovery, the adjusted reported concentrations range from 0.004% to 0.2% (see Table C-21), which is still below the conservative percentage of 0.5% methyl mercury assumed in the development of the 8.4-mg/kg final remediation goal. In Table C-21, the calculated percentages based on the method detection limit range from 0.004% to 0.3% and the calculated percentages based on the reported concentrations range from 0.001% to 0.1%. It is not valid to use the reported concentrations since they are below the method detection limit and are not accurate. These percentages merely indicate how low the actual percentage of methyl mercury in the soil might be. It also is not valid to use the method detection limit since it overestimates how much methyl mercury is in the sample.

C-7. REFERENCES

40 CFR 261.24, 2003, "Toxicity Characteristic," *Code of Federal Regulations,* Office of the Federal Register, January 2003.

40 CFR 268.40, 2003, "Applicability of Treatment Standards," *Code of Federal Regulations*, Office of the Federal Register, January 2003.

42 USC § 6901 et seq., 1976, "Resource Conservation and Recovery Act of 1976 (Solid Waste Disposal Act)," *United States Code*, October 21, 1976.

42 USC § 9601 et seq., 1980, "Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA/Superfund)," *United States Code,* December 11, 1980.

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Attachment C-1

Operating Procedure that the Laboratory used for the Methyl Mercury Analysis (Lot Numbers and Solution Numbers were used for In-Laboratory Tracking Purposes)

Attachment C-1

Operating Procedure that the Laboratory used for the Methyl Mercury Analysis (Lot Numbers and Solution Numbers were used for In-Laboratory Tracking Purposes)

Extraction

1 Add 0.5 G of sediment sample to 35 ml teflon centrifuge tube.

2 Add spk to LCSW and MS, MSD. Spk w/ 300 ul of 50 ppb CH3Hg Inorg. # 3385

3 Add 5 ml of solution containing 18% KBr Lot# 3582 and 5% H2SO4 Lot #2561.

4 Add 1 ml of 1 mol/L CuSO4 solution. Lot # 2215

5 Leach by shaking for 1 hour.

6 Add 10 ml of CH2Cl2. Place on shaker at high speed for 1 hour.

7 Centrifuge for 30 min. @ 2000 RPM, to separate aquous and organic layer.

8 Pipette out 2 ml of CH2Cl2 into a 60 ml Teflon purge vessel and add 45 ml of reagent water.

9 Cap with a purge cap and set in water bath for 30 min. at 45 C. with N2 flow at 20 cm/min.

10 Sample is ready for ethylation. Ethylate in the same 60 ml Teflon tube.

Ethylation

1 Using the same 60 ml Teflon purge vessel containing the 45 ml of sample.
2 Add 400 ul of 2 M acetate buffer #TMRL 02-002-06
3 Add 0.04 mL Of 1% NaBEt4 #TMRL ~~02-002-07~~ 02-CO4-01 5V 3/29/02
4 Cap reaction valve with caps with purging tubing inserted in cap. and swril gentle to mix.
5 Allow to stand for 17 min.

Purging

6 Attach tube to purging setup. One end of tube to N2 flow one end to CarboTrap.
Allow to purge for 17 min.

Drying

7 Attach the CarboTrap (marked side) to the drying setup.
Allow to dry for 7 min.

Desorption of Methyl Mercury

7 Attach CarbTrap (marked side) to Chromatograph and Ar flow to other side.
8 Hit F5 on spectrophotometer keyboard.

DATE: 5-29-02 SIGNATURE: BJ

Appendix D

Central Facilities Area-04 Mercury Pond Remedial Action Sampling Results

Author – John Giles

CONTENTS

FIGURES

TABLES

ACRONYMS

CEL	Chemical Engineering Laboratory
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFA	Central Facilities Area
DOE-ID	U.S. Department of Energy Idaho Operations Office (now DOE Idaho)
FFA/CO	Federal Facility Agreement and Consent Order
INEEL	Idaho National Engineering and Environmental Laboratory
NIST	National Institute of Standards and Technology
ROD	Record of Decision
TCLP	toxicity characteristic leaching procedure
TPR	technical procedure

Central Facilities Area-04 Mercury Pond Remedial Action Sampling Results

D-1. OVERVIEW

Field sampling of the Central Facilities Area (CFA)-04 mercury pond was performed just prior to, and concurrently with remedial action of the site during 2003 in accordance with the *Field Sampling Plan for the Central Facilities Area-04 Pond Remedial Action* (DOE-ID 2003a) (FSP). The governing Quality Assurance Project Plan (QAPjP) for the sampling effort was the *Quality Assurance Project Plan for Waste Area Groups 1, 2, 3, 4, 5, 6, 7, 10, and Deactivation, Decontamination, and Decommissioning* (DOE-ID 2004).

Field sampling at the CFA-04 mercury pond comprised field screening and confirmation sampling and on-Site analysis. Samples were also collected and sent to an offsite laboratory as quality control for the field analytical method. The primary purpose of the sampling effort was to provide near real-time analytical data regarding mercury concentrations of the underlying soils at the CFA-04 mercury pond remedial action, and to provide confirmation of the effectiveness of soil excavation in removing the mercury-contaminated soils.

D-2. SITE BACKGROUND

D-2.1 Site Description

The Idaho National Engineering and Environmental Laboratory (INEEL) is a government-owned/contractor-operated facility managed by DOE-Idaho and is located 51 km (32 mi) west of Idaho Falls, Idaho (Figure D-1). This facility occupies 2,305 km^2 (890 mi^2) of the northeastern portion of the Eastern Snake River Plain and encompasses portions of five Idaho counties: (1) Butte, (2) Jefferson, (3) Bonneville, (4) Clark, and (5) Bingham.

CFA has been used since 1949 to house many support services for all operations at the INEEL. These support services include laboratories, security operations, fire protection, medical facilities, communication systems, warehouses, a cafeteria, vehicle and equipment pools, the bus system, and laundry facilities. The *Federal Facility Agreement and Consent Order for the Idaho National Engineering Laboratory* (DOE-ID 1991) (FFA/CO) identified 52 potential release sites at CFA, which were designated as Waste Area Group (WAG) 4.

The CFA-04 pond was a shallow, unlined surface depression that was originally a borrow pit for construction activities at CFA (Figure D-2). The pond was approximately 46 × 152 m (150 × 500 ft) and roughly 2 to 2.4 m (7 to 8 ft) deep. Basalt outcrops are present both within and immediately adjacent to the pond area. It received laboratory wastes from the Chemical Engineering Laboratory (CEL) in Building CFA-674 between 1953 and 1969. The CEL was used to conduct calcine experiments on simulated nuclear wastes. The calcining process was later used on actual nuclear wastes at the INEEL to change them from a liquid to a solid, thereby reducing the overall waste. The CEL experiments used mercury to dissolve simulated aluminum fuel cladding as well as radioisotope tracers in the calcining process. The primary waste streams discharged to the pond from the CEL included approximately 76.5 m^3 (100 yd^3) of mercury-contaminated calcine that contained low-level radioactive wastes and liquid effluent from laboratory experiments. The pond received run-off from the CFA site periodically between 1953 and 1995.

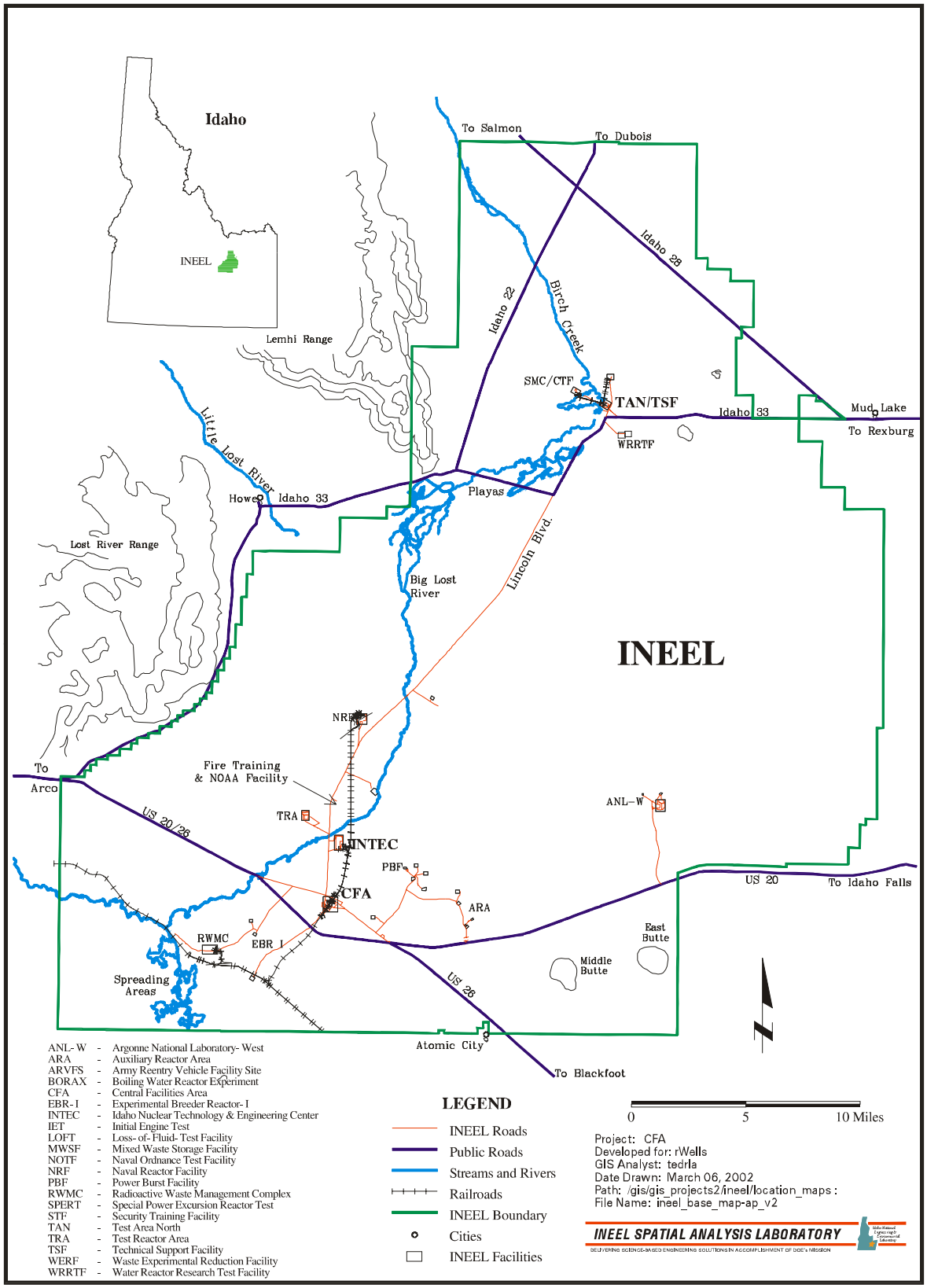

Figure D-1. Idaho National Engineering and Environmental Laboratory.

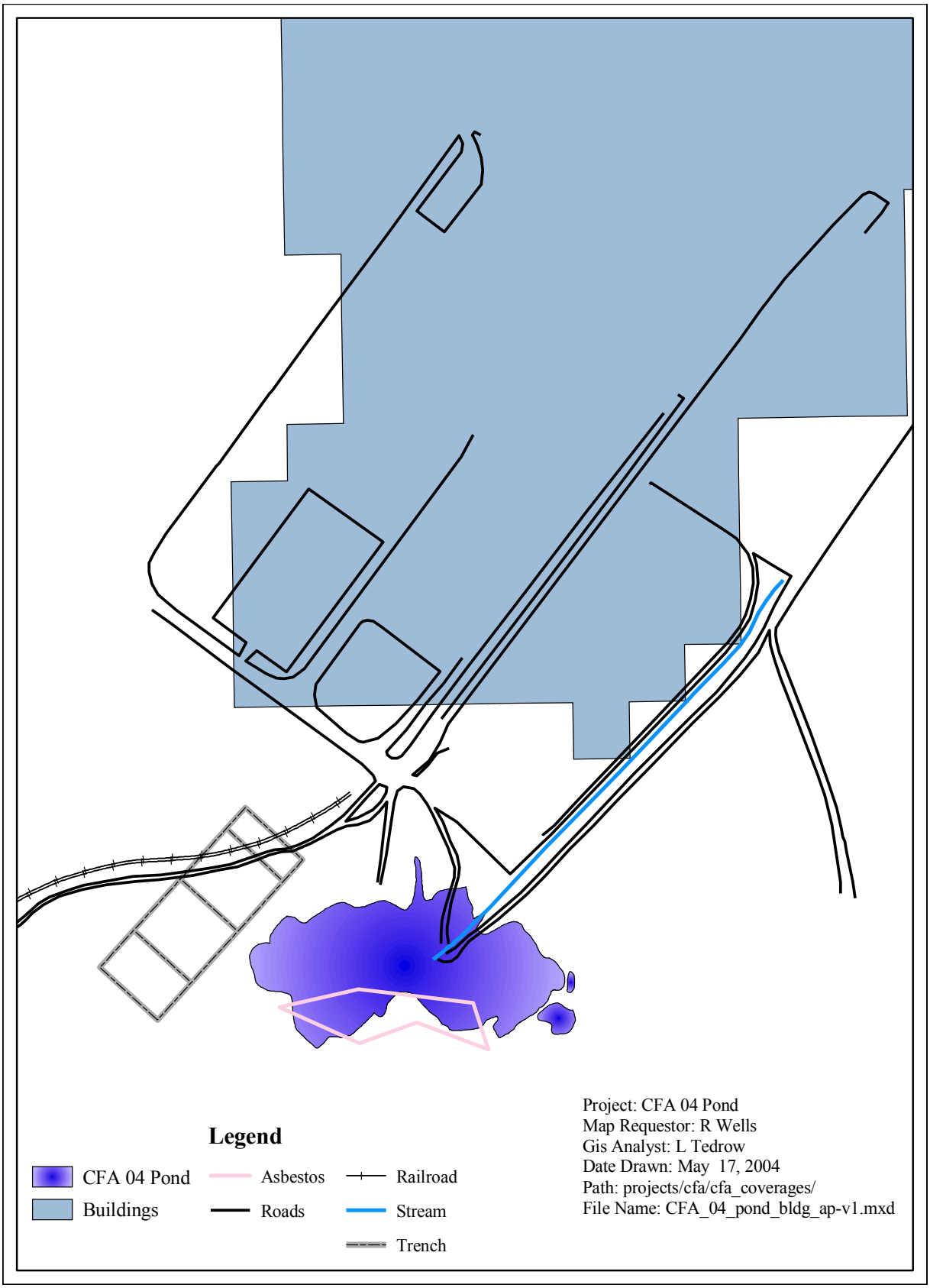

Figure D-2. Central Facilities Area, CFA-04 pond.

D-2.2 Nature and Extent of Contamination

The CFA-04 pond was identified as a Track 2 investigation site in the FFA/CO (DOE-ID 1991). Visual inspections in 1994 revealed the presence of calcine on the bermed areas around the periphery of the pond. After surface and subsurface soil data collection from the calcine and the pond berm in early and mid-1994, a time-critical removal action in September 1994 excavated approximately 218 m^3 (285 yd^3) of calcine and calcine-contaminated soil and a small amount of asbestos from the bermed area. The soil was remediated at a portable retort set up northeast of the pond. Verification soil sampling conducted after the removal action showed that, with the exception of one location having a mercury concentration of 233 mg/kg, the bermed areas had residual mercury concentrations less than the final remediation goal of 8.4 mg/kg (DOE-ID 2000a).

The *Final Comprehensive Record of Decision for Central Facilities Area Operable Unit 4-13* (DOE-ID 2000b) (Record of Decision or ROD) originally established a final remediation goal of 0.5 mg/kg for mercury contamination at CFA-04. This was an ecological goal based on 10 times the average background concentration for composite samples. It was determined that a re-evaluation of the final remediation goal for mercury was warranted for both human and ecological receptors after new information became available from Environmental Protection Agency (EPA) sources. Based on this new information, hazard quotients were recalculated for the existing concentration of mercury at the CFA-04 pond. For the future residential exposure scenario, the recalculated hazard quotient is 7.56 as compared to 80 from the ROD (DOE-ID 2000b). For the ecological risk assessment, the recalculated values are < 1 to 210 as compared to <1 to 30,000 from the ROD (DOE-ID 2000b). Based on this new information, the recalculated remediation goals for ecological and human health risk are 8.4 mg/kg and 9.4 mg/kg, respectively. The recalculated remediation goals for both human health and ecological receptors are consistent with the remedial action objectives for the CFA-04 pond.

D-2.3 Project Description

The sampling and analysis objectives conducted for the CFA-04 remedial action were as follows:

1. Fill data gaps with additional preremediation sampling in the windblown area identified after the preremediation sampling in 2002, to ensure that all mercury-contaminated soil exceeding the remedial action goal was identified for removal.

2. Provide field-screening data of underlying soils by identifying (a) areas where the remedial action goal was met, and (b) areas which required further excavation

3. Provide confirmation that the remedial action objectives for the CFA-04 Pond were met as stipulated in the ROD (DOE-ID 2000b), and in the *Explanation of Significant Differences for the Record of Decision for the Central Facilities Area, Operable Unit 4-13* (DOE-ID 2003b) (ESD).

Consistent with the objectives identified for the CFA-04 remedial action sampling, surface and subsurface soil samples were collected at locations across the site. Preremediation samples and confirmation samples were collected to support the data quality objectives (DQOs) as identified in the project field sampling plan (DOE-ID 2003a).

D-3. SAMPLING LOCATIONS

The following subsections discuss the sampling location and frequency for additional preremediation sampling, and the confirmation and quality assurance/quality control (QA/QC) sampling.

D-3.1 Preremediation Samples

Additional windblown calcine was discovered outside the bounds of known contamination and was confirmed by analysis of a grab sample to contain mercury above the remedial action goal using an on-Site mercury analyzer. The preremediation sampling of the windblown area was conducted in two phases. First, a 7.6 × 7.6-m (25 × 25-ft) grid was established over the potentially contaminated area. Surface soil samples 0 to 15 cm (0 to 6 in.) were collected from each grid node, as indicated in Figure D-3. Based on these data, the horizontal boundaries of the proposed excavation zone were established. The second phase of the sampling effort involved the collection of 15-cm (6-in.) core samples to a depth of 0.6 m (2 ft) within the established horizontal boundaries to define the vertical boundaries of the excavation. Four core sample locations (Figure D-4) were randomly selected (based on the same 7.6 × 7.6-m (25 × 25-ft) grid), and the 15-cm (6-in.) core samples were collected. The 15-cm (6-in.) segments of each core were combined into a single composite sample for each depth interval, providing a total of four composite samples, each representative of the defined depth interval. These samples were submitted to the analytical laboratory for total mercury, toxicity characteristic leaching procedure (TCLP) metals and radionuclide analyses.

D-3.2 Confirmation Samples

Confirmation samples were collected in conjunction with field screening activities. As described in the field sampling plan, a minimum of 40 confirmation samples were to be collected from excavated areas where underlying soils remained, and analyzed using the field mercury analysis system. Field sampling was performed randomly during and after excavation activities to determine the levels of mercury contamination in the remaining soils. Although field samples were collected from throughout all excavated areas of the pond, 77 samples (including quality control samples) were collected for purposes of confirmation that the remedial action objectives had been achieved from areas of the pond that were not excavated to basalt. Confirmation sampling locations are shown in Figure D-5. Confirmation samples were collected, with a minimum of 20% of the samples collected along the vertical surfaces of the excavation. Areas of the CFA-04 pond that were excavated to basalt were specifically excluded from evaluation of the efficacy of the remedial action. The exposure pathway in the areas excavated to basalt was included in the final analysis of the remaining contamination at the CFA-04 Pond described by VanHorn and Stacey (2003).

Quality assurance samples were also collected, as identified in the FSP (DOE-ID 2003a), to serve as quality control for the field mercury analysis system. A minimum of 10% of the confirmation samples were identified as quality assurance samples for field instrumentation. A total of eight sample locations were selected at random from the 7.6 × 7.6-m (25 × 25-ft) grid identified in Section 3.1 above, with a duplicate collected at one of the locations. These quality assurance sample locations are identified in Figure D-6.

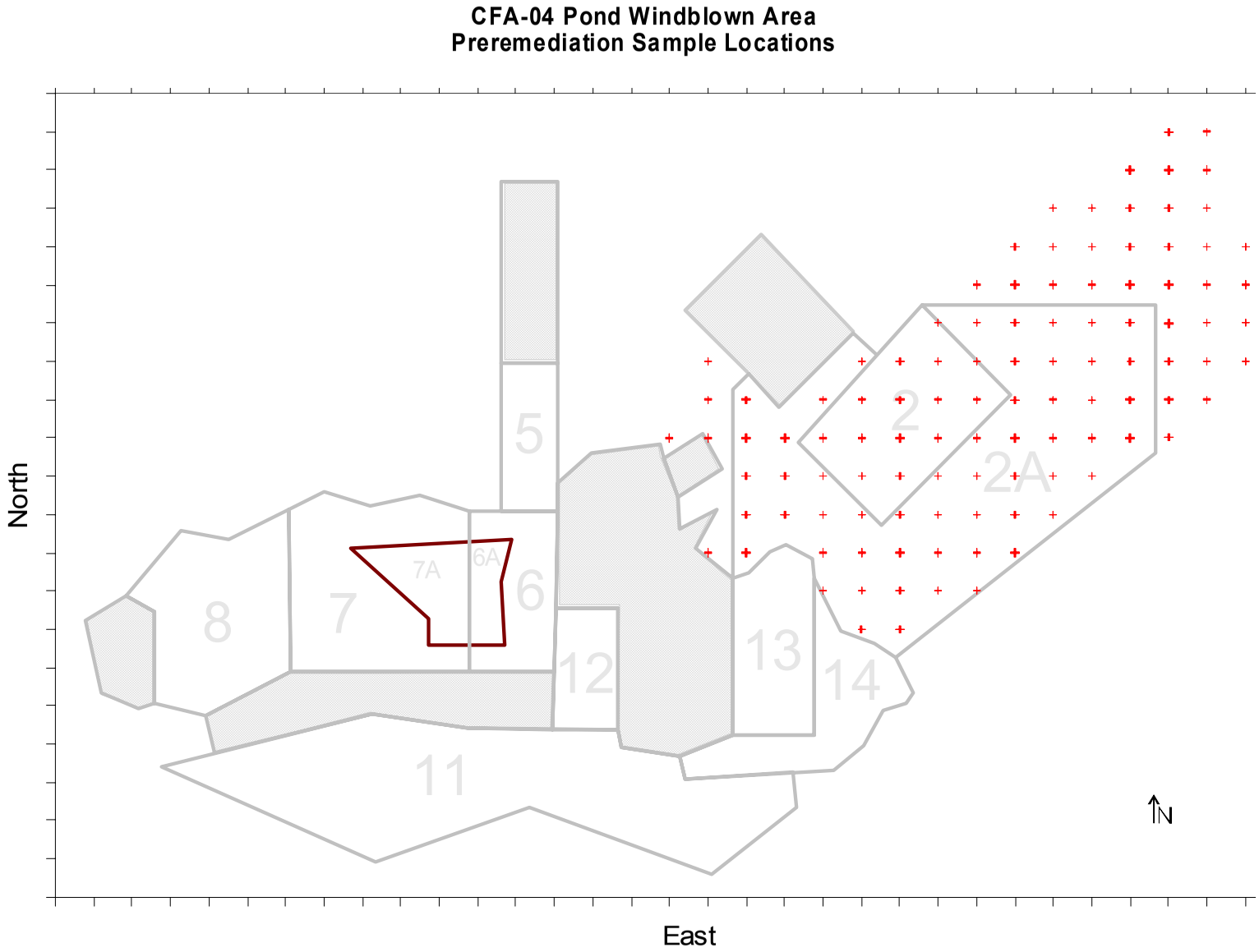

Figure D-3. Central Facilities Area, CFA-04 preremediation sampling locations, Phase One.

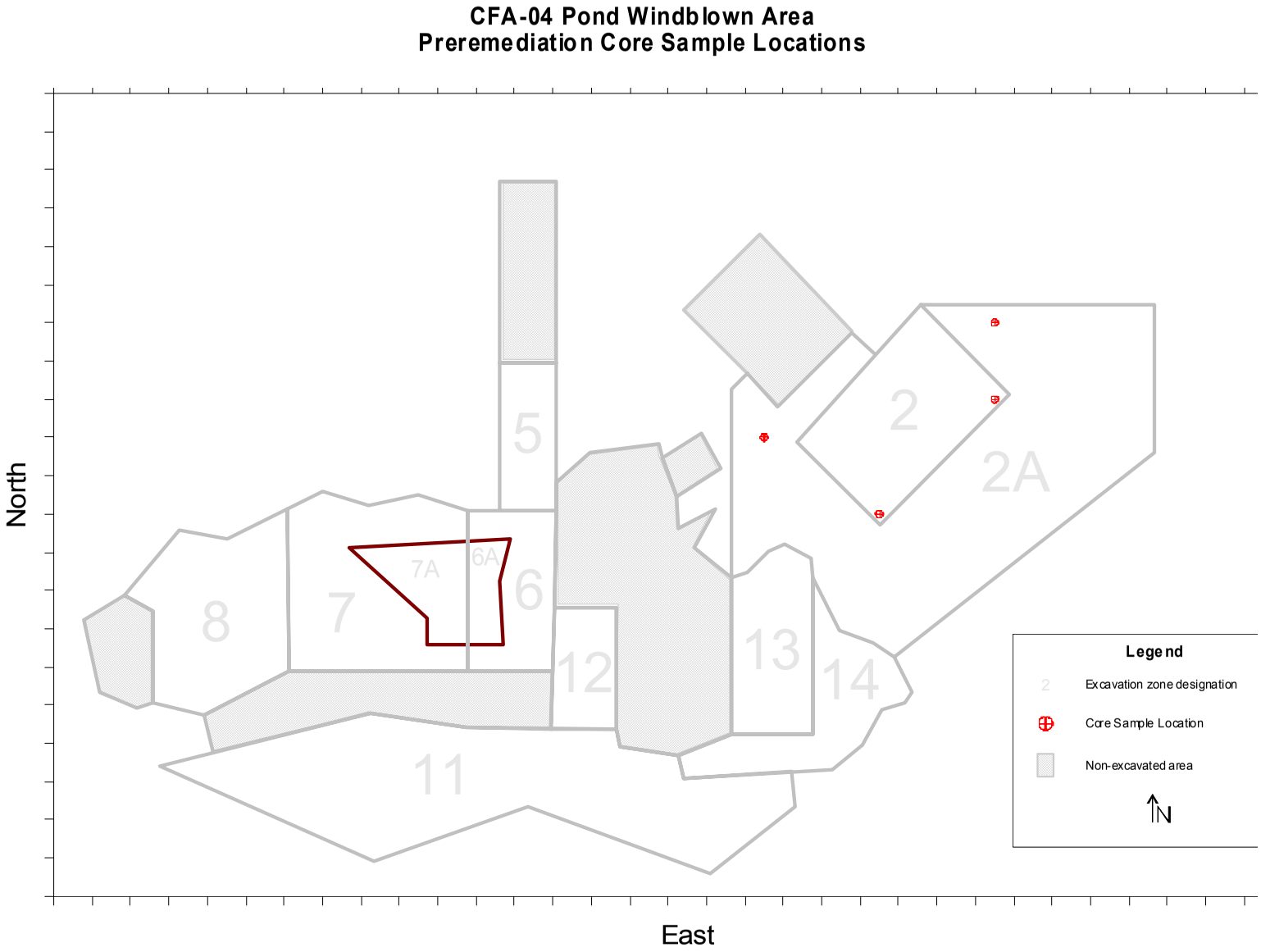

Figure D-4. Central Facilities Area, CFA-04 preremediation sampling core locations.

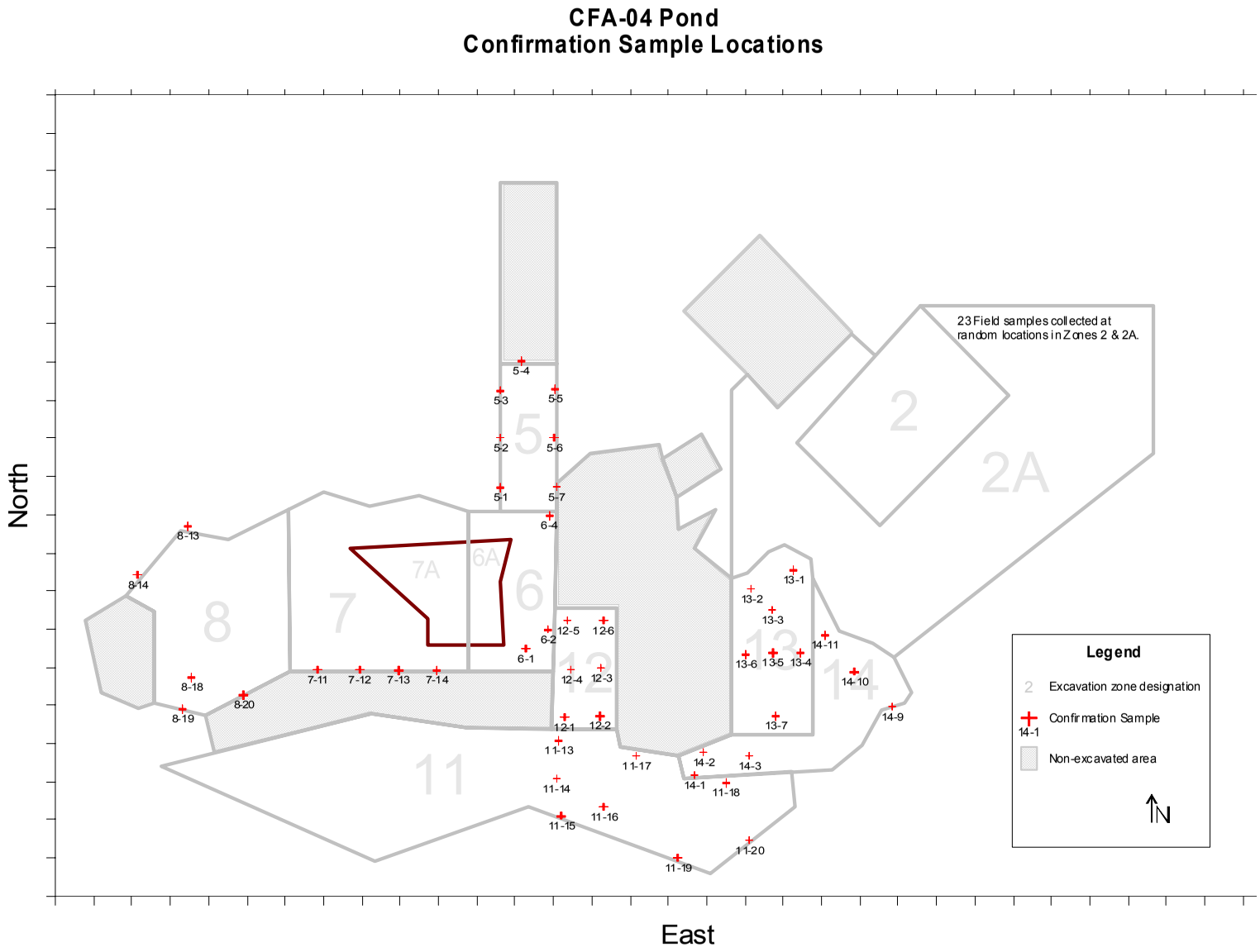

Figure D-5. Central Facilities Area, CFA-04 confirmation sample locations, excluding quality assurance confirmation samples.

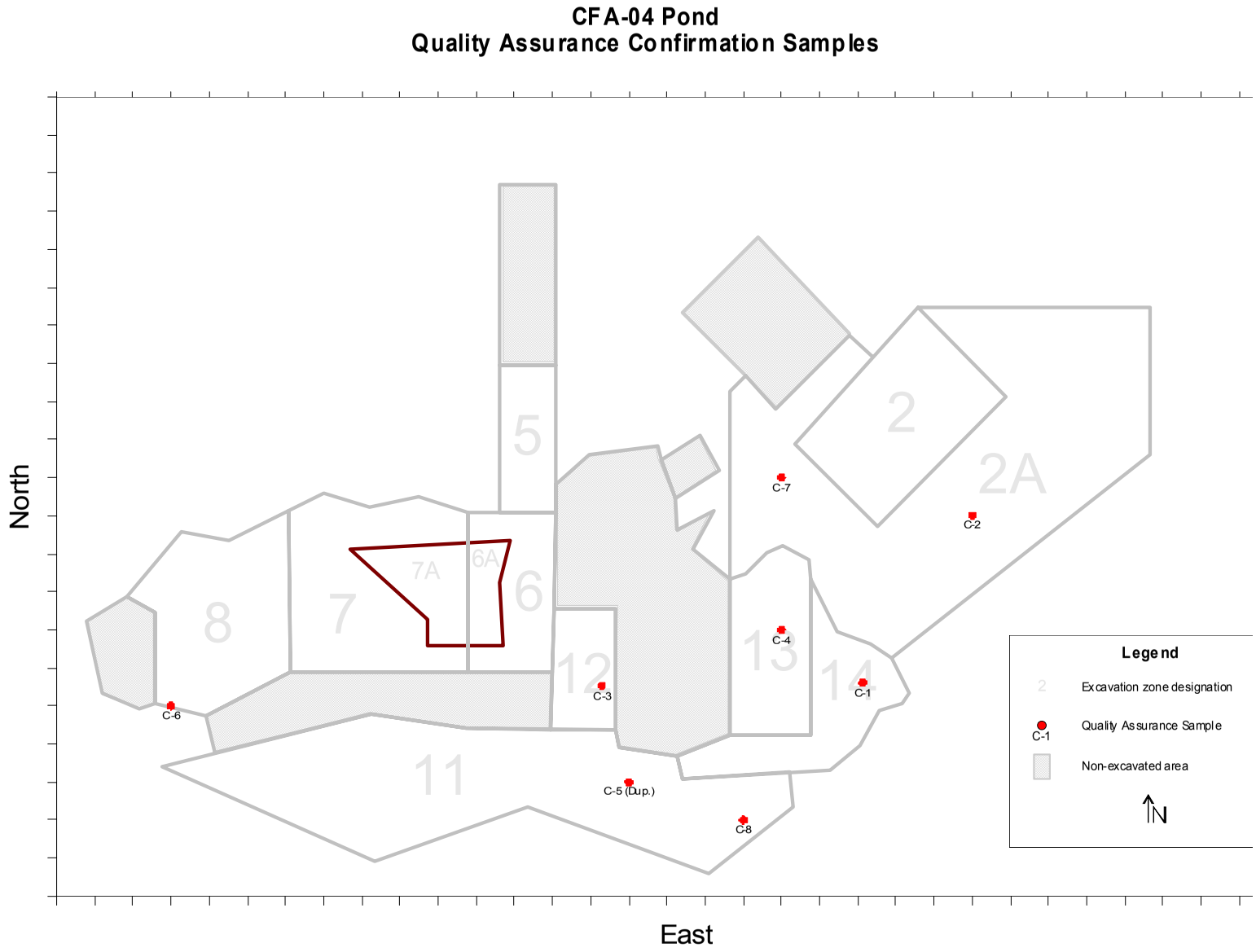

Figure D-6. Central Facilities Area, CFA-04 quality assurance confirmation sample locations.

D-4. SAMPLING PROCEDURES AND EQUIPMENT

The following subsections describe the sampling procedures and equipment that were used for the CFA-04 remedial action sampling and analyses.

D-4.1 Site Preparation

All required documentation and safety equipment were available at the sampling site including radios, fire extinguishers, personal protective equipment, sample containers, and sampling tools and equipment.

D-4.2 Sample Collection

Collection of the surface samples during the preremediation sampling utilized clean sampling scoops, spoons, and shovels. Samples were collected in accordance with INEEL procedures which outlined how to collect samples using scoops, spoons, and shovels. Discrete grab samples were collected from 0 to 15 cm (0 to 6 in.), placed in the appropriate clean containers, and transferred to the onsite laboratory for analysis of total mercury.

Collection of the core samples during the preremediation sampling required the use of a hand corer, which was done in accordance with INEEL procedures outlining how to collect samples using a hand corer. The core samples were subdivided into 15-cm (6-in.) depth intervals, and the analytical sample submitted to the laboratory consisted of a composite of the individual core samples collected at discrete depths. The individual sample aliquots were thoroughly mixed, and the composite sample aliquots collected using disposable sampling spoons. The aliquots were placed in certified, precleaned sample containers with an appropriate sample label affixed that had been obtained from Sampling and Analysis Management. Table D-1 identifies the specific sample analytical requirements for the field and laboratory samples.

Table D-1. Specific sample analytical requirements.

Analyte	Analytical Method	Preliminary Action Level (mg/kg or pCi/g)	Practical Quantitation Limit (mg/kg or pCi/g)
Hg	Field Analyzer	8.4	0.05
	SW-846 Method 7471A [a]		0.2
TCLP Hg	SW-846 Method 7471A [a]	0.2 mg/L	0.2 µg/L
TCLP Cr		5.0 mg/L	10 µg/L
TCLP Ag		5.0 mg/L	10 µg/L
Radionuclides			
U Isotopes	Alpha spec.	1.04 (U-234,8), 0.048 (U-235)	0.05 (U-234,5,8)
Strontium-90	GFPC	0.26	0.1
Gamma-emitters	Gamma spec.	0.44 (Cs-137)	0.1

a. EPA Method 7471A, 1994, "Mercury in Solid or Semisold Waste (Manual Cold-Vapor Technique)," Rev. 1, SW-846, *Test Methods for Evaluating Solid Wastes – Physical/Chemical Methods*, U.S. Environmental Protection Agency, September 1994.

GFPC = gas-flow proportional counter

TCLP = toxicity characteristic leaching procedure

D-4.3 Decontamination

All sampling equipment that came into contact with the sample media was decontaminated following INEEL procedures for decontaminating sampling equipment. Dry decontamination methods were used to eliminate the generation of liquid decontamination waste.

D-4.4 Mercury Analysis

Mercury analyses were performed on soil samples using onsite and offsite laboratories. Offsite analyses were performed by an approved, qualified laboratory. The laboratory used SW-846 EPA Method 7471A (1994) for analysis of mercury in solids.

Onsite analysis was performed using a field analytical technique. The Zeeman Mercury Analyzer RA-915+ operates on the principle of thermal decomposition of the sample, allowing for direct measurement of mercury using atomic absorption spectrometry. Coupled with the RP-91C Pyrolysis Attachment, the instrument is capable of achieving detection limits on the order of less than 1 μg/kg using a 200-mg soil sample. The instrument was operated in accordance with the manufacturer's instructions.

The field instrument was calibrated for efficiency each day it was used prior to analysis of the field samples. The calibration was performed following the manufacturer's procedures, using National Institute of Standards and Technology (NIST) certified soil standards: 1) Standard Reference Material No. 2710 certified at 32.6 ± 1.8 mg/kg total mercury (NIST 2003a), and 2) Standard Reference Material No. 2711 certified at 6.25 ± 0.19 mg/kg total mercury (NIST 2003b).

Succinctly, field analysis for mercury was conducted in the following manner:

1. Calibrate instrument using NIST standards
2. Obtain sample aliquot for analysis and measure its mass (mg)
3. Enter sample description and mass into field instrument software
4. Place sample aliquot in analyzer
5. Start analysis
6. Upon completion of the day's analyses, software automatically computes total mercury concentration of the sample, and the file (including calibration data) is saved to the analysis computer hard drive.

D-5. ANALYTICAL RESULTS

The following subsections summarize the sampling and analysis results for the CFA-04 remedial action sampling summary.

D-5.1 Additional Preremediation Sampling

The preremediation sampling was conducted in two phases (Phase I and Phase II) to define, respectively, the horizontal and vertical extent of mercury contamination exceeding the remedial action goal of 8.4 mg/kg.

Figure D-7 displays the field analytical results from the first phase of sampling. The analytical data are contained in Attachment D1.

As shown in Figure D-7, the horizontal boundary of the mercury contamination in this windblown area adjacent to the pond was conservatively set as depicted by the outline of Zone 2A. The mercury concentrations in this windblown area ranged from 0.032 mg/kg to 82.4 mg/kg.

The second phase of sampling comprised four core samples composited for four discrete depth intervals: (a) 0 – 15 cm (0 – 0.5 ft), (b) 15 – 30 cm (0.5 – 1.0 ft), (c) 30 – 45 cm (1.0 – 1.5 ft), and (d) 45 – 60 cm (1.5 – 2.0 ft). The results of the core sampling are summarized in Table D-2. As shown in the table, the only man-made radionuclide detected was Cs-137 at a maximum concentration of 1.77 +/- 0.199 E-01 at a depth of 0 – 15 cm (0 – 0.5 ft), which is consistent with background values associated with fallout from atmospheric weapons testing. Strontium-90 was not detected in any of the core samples. The uranium isotopes U-234 and U-235 were detected in all samples at values consistent with INEEL background values (Rood et al. 1996). Elevated levels of mercury near the remedial action goal were identified at a depth of 0 – 15 cm (0 – 0.5 ft) with a maximum concentration of 7.77 mg/kg. The vertical extent of contamination for Zones 2 and 2A was set at a depth of 0.5 ft for excavation during the remedial action.

Table D-2. Preremediation sampling Phase II, Zone 2A results.

Sample ID:	4R405101		4R405102 (Dup.)		4R405201		4R405301		4R405401	
Interval (ft):	0-0.5		0-0.5		0.5-1.0		1.0-1.5		1.5-2.0	
Gamma Spec. (pCi/g)										
Cs-137	1.38 +/- 0.206 E-01		1.77 +/- 0.199 E-01		2.47 +/- 1.55 E-02	U	0.527 +/- 1.08 E-02	U	1.60 +/- 8.41 E-02	U
Sr-90 (pCi/g)	2.73 +/- 1.22 E-02	U	3.32 +/- 1.31 E-02	U	3.92 +/- 1.40 E-02	U	1.44 +/- 0.960 E-02	U	7.90 +/- 9.90 E-03	U
Uranium Iso. (pCi/g)										
U-234	9.27 +/- 1.94 E-01		1.09 +/- 0.224 E+00		9.25 +/- 1.94 E-01		8.41 +/- 1.86 E-01		1.01 +/- 0.216 E+00	
U-235	5.79 +/- 4.74 E-02	U	1.76 +/- 0.892 E-01	U	1.67 +/- 0.907 E-01	U	7.25 +/- 9.93 E-02	U	2.96 +/- 5.60 E-02	U
U-238	1.18 +/- 0.221 E+00		7.48 +/- 1.85 E-01		7.46 +/- 1.73 E-01		1.03 +/- 0.206 E+00		6.74 +/- 1.71 E-01	
Mercury (mg/kg)	7.23		7.77		0.199		0.358		0.156	
TCLP Metals (µg/L)										
Chromium	0.014	U	0.014	U	0.014	U	0.014	U	0.014	U
Mercury	0.001	U	0.001	U	0.001	U	0.001	U	0.001	U
Silver	0.025	U	0.025	U	0.025	U	0.025	U	0.025	U

ID = identification
TCLP – toxicity characteristic leaching procedure

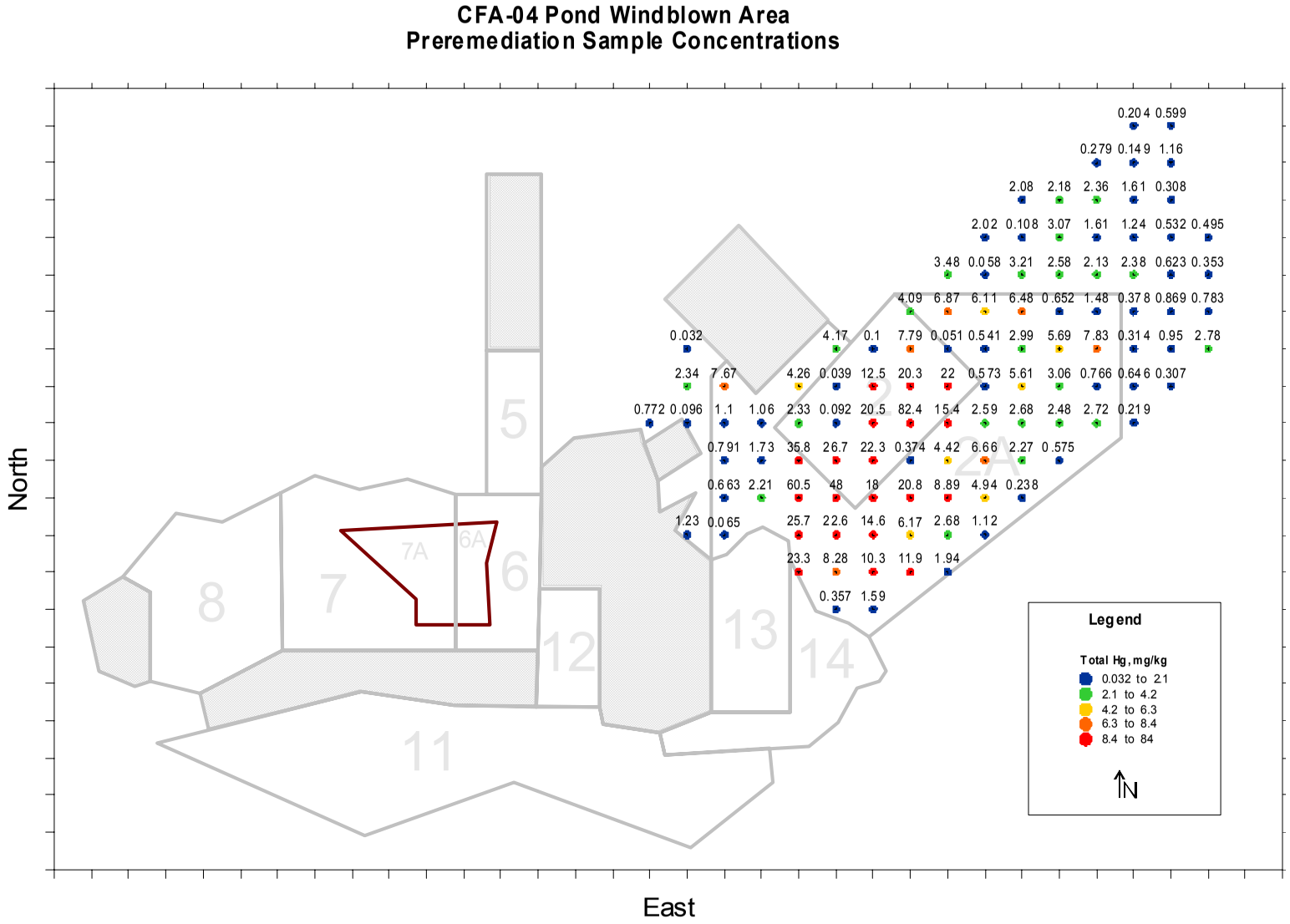

Figure D-7. Central Facilities Area, CFA-04 preremediation sampling results.

D-5.2 Confirmation Sampling

The initial removal of soil at the CFA-04 pond was based on the analytical results obtained from preremediation sampling events during the summers of 2002 and 2003. Upon removal of the soil to the depths identified in the design specifications for remedial action (DOE-ID 2003c), the excavated areas were sampled, and the samples were analyzed onsite using the field mercury analyzer. The field results were used to identify areas that required further excavation in order to achieve the remedial action goal of 8.4 mg/kg. Upon completion of excavation, confirmation samples were collected throughout the entire excavated area of the pond, and only those areas where the excavation did not reach the basalt interface were considered in the evaluation of the site meeting the remedial action goal. Figures D-8a and D-8b display results of the confirmation sampling of these areas. The confirmation sampling results are also tabulated in Attachment D2 of this summary report.

The confirmation sampling included the collection of nine quality control samples (including one duplicate) to demonstrate the correlation between the field analyzer and offsite laboratory data. A correlation study was performed during the summer of 2002 where 61 samples from the CFA-04 pond, with mercury concentrations ranging from 7 μg/kg to 127 mg/kg, were analyzed using the field mercury analyzer and an offsite laboratory. The Pearson correlation calculated for the paired data was 0.89, demonstrating good correlation between the two analytical methods (DOE-ID 2003a).

A similar correlation was performed during confirmation sampling upon completion of excavation at the CFA-04 pond. The quality control data is presented in Table D-3, and plotted in Figure D-9.

Table D-3. Quality control data.

Sample Number/Location	Field Analyzer Concentration, mg/kg	Laboratory Concentration, mg/kg	Laboratory Flag
4R400101HG/C-1	0.1	0.233	R
4R400201HG/C-2	0.1	0.0592	R
4R400301HG/C-3	1.6	4.83	R
4R400401HG/C-4	7.1	5.52	R
4R400501HG/C-5	28	27.2	R
4R400502HG/C-5 (duplicate)	25	25.7	R
4R400601HG/C-6	0.1	0.308	UJ
4R400701HG/C-7	3.7	3.970	J
4R400801HG/C-8	60	36.4	J
Mean	14.0	11.6	
Pearson Correlation	0.96		

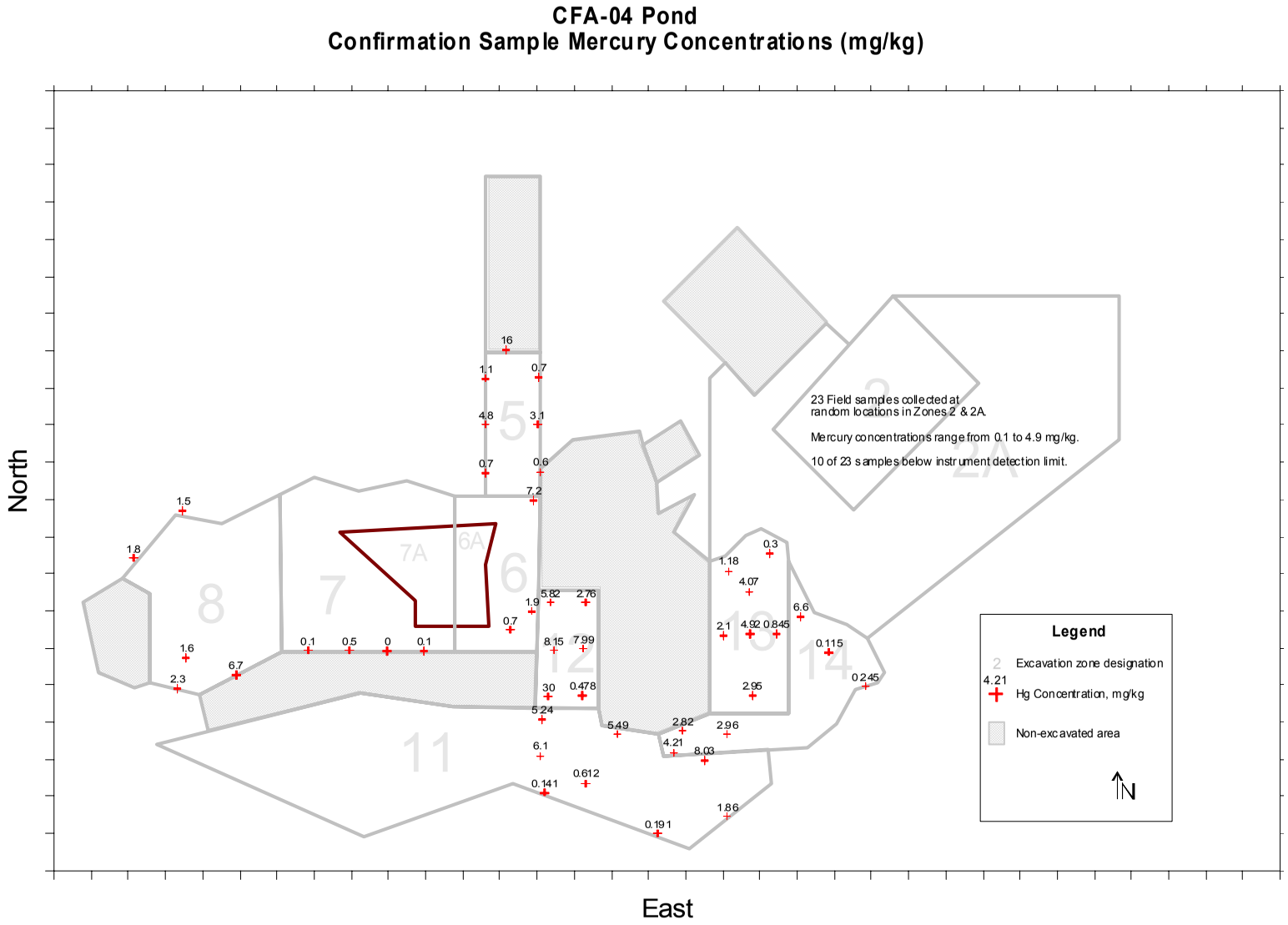

Figure D-8a. Central Facilities Area, CFA-04 confirmation sampling total mercury concentrations.

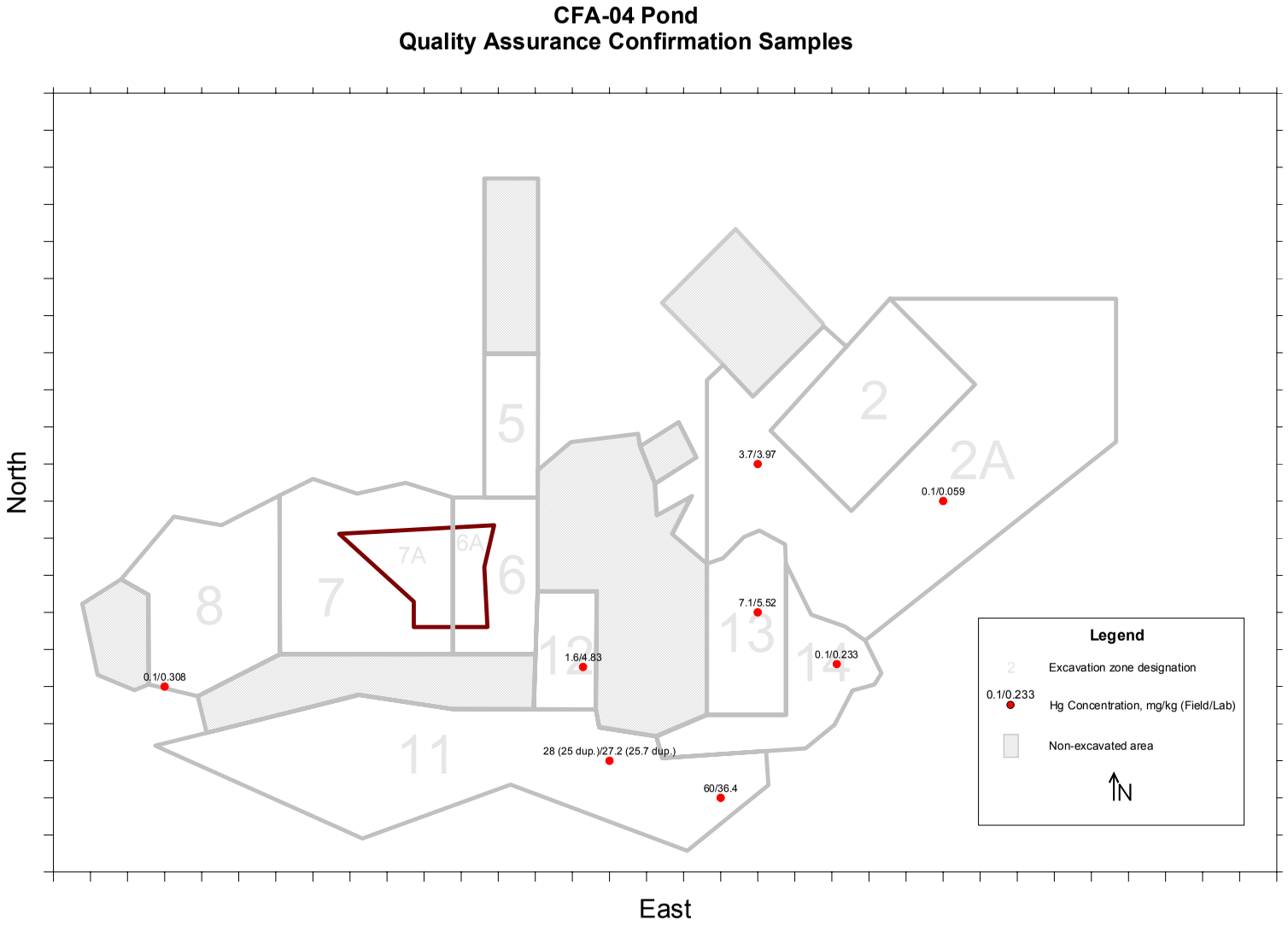

Figure D-8b. Central Facilities Area, CFA-04 quality assurance confirmation sample concentrations.

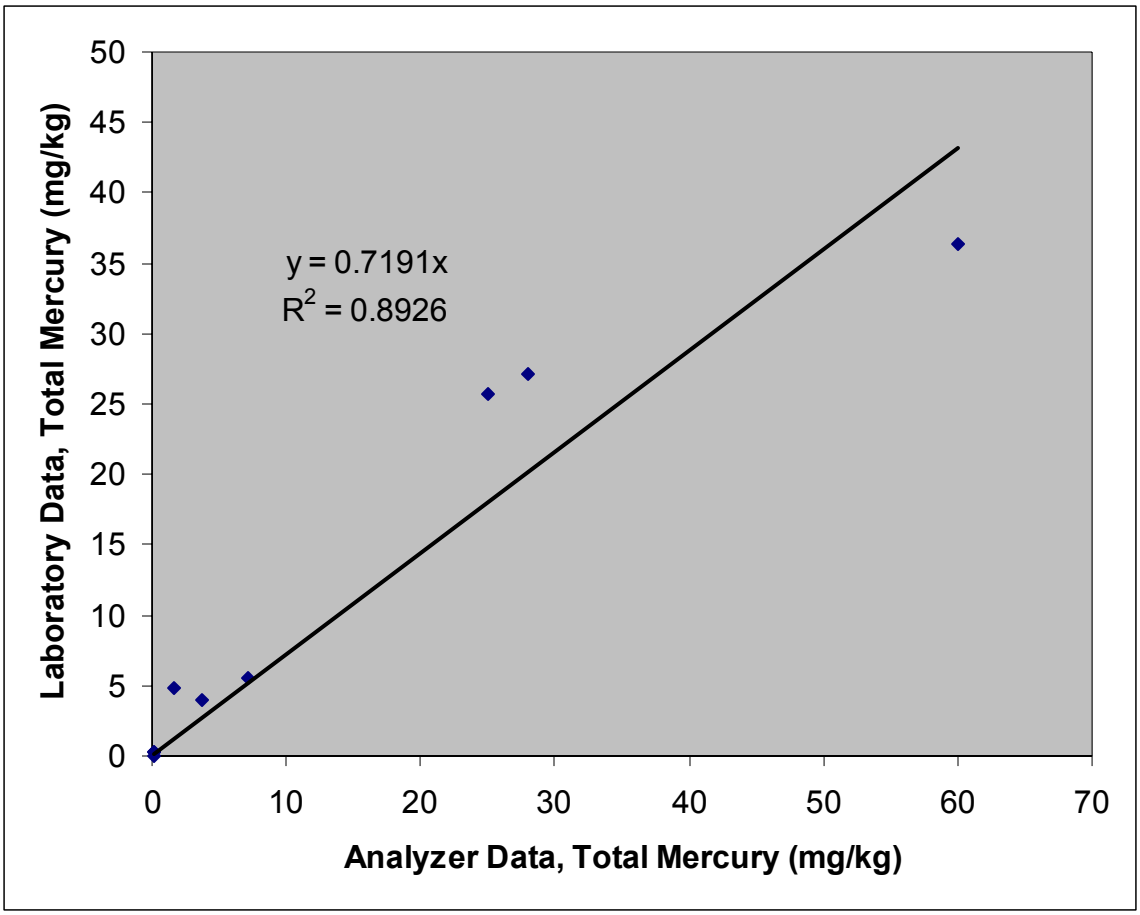

Figure D-9. Quality control correlation between field mercury analyzer and laboratory.

The Pearson correlation calculated for the nine pairs of quality control data is 0.96, which is consistent with the previous correlation study, and further demonstrates good correlation between the data.

It should be noted that the first five samples that were analyzed by the laboratory are qualified with an "R" (Reject) due to poor agreement between the field sample used for laboratory quality control analysis and its laboratory-generated duplicate (52.2% relative percent difference). Additionally, the matrix spike sample did not agree well with the matrix spike duplicate sample (46.3% relative percent difference). The laboratory's case narrative states that the sample used for quality control (QC) analysis (4R400101HG) "was not homogeneous in appearance. It was a tan sand containing rocks and pebbles." However something to consider is that the results for sample 4R400501HG and its field duplicate, 4R400502HG, did agree well (5.7% relative percent difference). This is inconsistent with the other field samples collected in that the other samples were homogenous in physical composition and appearance (Thompson 2004). Additionally, the other three sample results were also qualified: 1) one sample (4R400601HG) was qualified with a "UJ," categorized as definitive data with a non-detect analyte concentration that is an estimate due to positive blank detections and low matrix spike/matrix spike duplicate recoveries, 2) two samples (4R400701HG and 4R400801HG) were qualified with a "J," categorized as definitive data with a detectable analyte concentration that is an estimate due to low matrix spike/matrix spike duplicate recoveries.

Although five of the laboratory sample data values were qualified with an "R," the data generated by the field mercury analyzer was consistent with the laboratory reported values, and as noted in the field analyzer logbook, none of the quality control sample values reported were from analyses that fell outside the defined calibration range of the instrument.

D-5.3 Confirmation Data Assessment

After collection and analysis, the confirmation sampling data was evaluated against the remedial action goal, as identified in the field sampling plan (DOE-ID 2003a). First the data were tested for normality. Normality was established through use of the Shapiro-Wilk (S-W) statistic and its associated p-value for the non-transformed data, and data transformed using two methods: 1) natural logarithm transform, and 2) square root transform. The data set with the highest S-W statistic and lowest p-value was then selected as the data set for further analysis. While they don't achieve strict normality, there is a marked improvement when using the natural log transformation. The slight departure from normality has little effect on the results of the analysis. There were 11 measurements with the laboratory instrument that were less than the method detection limit; these values were excluded from the calculation of the 95% upper confidence limit (UCL). The 95% upper confidence limit on the mean was calculated The S-W statistics and p-values are listed in Attachment D2.

The results of the statistical analyses are that the 95% UCL for the data is 0.820. The transformed value of the final remediation goal is $ln(8.4+0.11) = 2.14$. Therefore, at a 95% confidence level it can be concluded that the average mercury contamination in the soils remaining at the CFA-04 pond is less than the final remediation goal of 8.4 mg/kg.

D-6. REFERENCES

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Attachment D1

Central Facilities Area, CFA-04
Preremediation Sampling Data

Table D1-1. Central Facilities Area-04 preremediation sampling data.

SAMPLE ID	NORTH	EAST	ELEVATION	Hg, mg/kg
6212	677500.00	293550.00	4930.04	2.33
6213	677475.00	293575.00	4928.13	26.7
6214	677500.00	293575.01	4929.55	0.092
6215	677524.99	293575.01	4930.73	0.039
6216	677474.99	293600.00	4928.77	22.3
6217	677499.98	293600.02	4928.84	20.5
6218	677525.00	293600.01	4929.81	12.5
6219	677550.00	293599.99	4930.45	0.1
6220	677499.99	293625.03	4929.46	82.4
6221	677525.01	293624.99	4930.53	20.3
6222	677550.02	293624.94	4930.42	7.79
6223	677575.00	293625.01	4930.24	4.09
6224	677525.00	293650.00	4930.59	22
6225	677550.00	293650.00	4931.10	0.051
6226	677500.01	293449.99	4927.16	0.772
6227	677425.01	293474.96	4926.71	1.23
6228	677499.99	293475.03	4927.92	0.096
6229	677525.01	293474.97	4928.26	2.34
6230	677550.00	293474.99	4929.01	0.032
6231	677424.99	293500.03	4927.35	0.065
6232	677450.01	293499.98	4928.26	0.663
6233	677474.99	293500.01	4926.21	0.791
6234	677500.01	293499.98	4928.55	1.1
6235	677525.00	293500.03	4928.67	7.67
6236	677450.01	293524.99	4927.74	2.21
6237	677474.99	293525.00	4928.83	1.73
6238	677499.98	293525.06	4927.44	1.06
6239	677400.01	293549.98	4921.58	23.3
6240	677425.00	293549.99	4926.31	25.7
6241	677450.01	293549.98	4927.36	60.5
6242	677475.01	293549.98	4928.44	35.8
6243	677525.01	293550.00	4927.88	4.26
6244	677375.02	293574.95	4922.77	0.357
6245	677400.00	293574.99	4927.98	8.28
6246	677425.00	293575.01	4927.92	22.6
6247	677450.00	293575.01	4927.93	48
6248	677549.96	293575.00	4928.05	4.17
6249	677374.98	293600.02	4927.97	1.59

Table D1-1. (continued).

SAMPLE ID	NORTH	EAST	ELEVATION	Hg, mg/kg
6250	677400.00	293600.00	4927.43	10.3
6251	677425.01	293600.01	4927.64	14.6
6252	677450.00	293600.00	4928.06	18
6253	677400.01	293625.00	4927.51	11.9
6254	677424.99	293625.02	4927.82	6.17
6255	677450.00	293625.00	4928.29	20.8
6256	677475.00	293624.99	4928.74	0.374
6257	677400.02	293649.95	4927.87	1.94
6258	677425.00	293649.99	4927.89	2.68
6259	677449.99	293650.01	4928.27	8.89
6260	677474.99	293650.01	4928.95	4.42
6261	677500.00	293650.01	4929.54	15.4
6262	677575.03	293650.01	4930.39	6.87
6263	677599.94	293649.99	4930.29	3.48
6264	677425.02	293675.01	4927.97	1.12
6265	677449.91	293674.97	4928.47	4.94
6266	677474.98	293675.00	4929.00	6.66
6267	677499.94	293674.98	4929.38	2.59
6268	677524.95	293674.99	4929.81	0.573
6269	677549.99	293675.00	4930.00	0.541
6270	677574.98	293675.00	4929.92	6.11
6271	677599.98	293675.00	4929.62	0.058
6272	677625.01	293675.01	4929.91	2.02
6273	677449.96	293699.98	4928.44	0.238
6274	677474.96	293699.99	4928.66	2.27
6275	677499.96	293699.99	4929.11	2.68
6276	677525.01	293700.01	4929.49	5.61
6277	677549.95	293699.99	4929.99	2.99
6278	677574.99	293700.00	4930.52	6.48
6279	677600.00	293700.00	4930.35	3.21
6280	677624.98	293699.99	4930.10	0.108
6281	677650.02	293700.01	4929.71	2.08
6282	677474.98	293724.99	4928.93	0.575
6283	677500.02	293725.00	4929.04	2.48
6284	677524.95	293724.98	4929.41	3.06
6285	677550.00	293725.00	4929.80	5.69
6286	677575.06	293725.02	4930.95	0.652
6287	677599.96	293724.99	4930.66	2.58

Table D1-1. (continued).

SAMPLE ID	NORTH	EAST	ELEVATION	Hg, mg/kg
6288	677625.06	293725.02	4930.22	3.07
6289	677650.05	293725.02	4930.06	2.18
6290	677499.93	293749.97	4929.10	2.72
6291	677525.01	293750.02	4929.46	0.766
6292	677550.05	293750.04	4930.26	7.83
6293	677575.00	293749.99	4930.43	1.48
6294	677600.01	293750.00	4929.85	2.13
6295	677624.95	293749.98	4930.38	1.61
6296	677650.02	293750.01	4930.10	2.36
6297	677674.93	293749.98	4929.92	0.279
6298	677500.12	293775.08	4928.99	0.219
6299	677525.01	293775.01	4929.28	0.646
6300	677549.93	293774.97	4929.73	0.314
6301	677574.94	293774.97	4930.38	0.378
6302	677600.01	293775.01	4930.14	2.38
6303	677624.97	293774.99	4930.08	1.24
6304	677650.03	293775.02	4930.68	1.61
6305	677674.96	293774.99	4930.40	0.149
6306	677700.00	293775.00	4929.99	0.204
6307	677524.98	293799.99	4929.15	0.307
6308	677549.98	293799.98	4929.40	0.95
6309	677574.99	293800.01	4929.26	0.869
6310	677599.95	293799.98	4929.56	0.623
6311	677625.00	293800.00	4929.60	0.532
6312	677650.06	293800.02	4929.94	0.308
6313	677674.98	293799.99	4929.94	1.16
6314	677700.04	293800.03	4929.73	0.599
6315	677549.99	293824.99	4929.28	2.78
6316	677575.00	293825.00	4929.01	0.783
6317	677600.02	293825.01	4929.29	0.353
6318	677625.02	293825.01	4929.37	0.495

Attachment D2

Central Facilities Area, CFA–04 Confirmation Sampling Data

Table D2-1. Confirmation Sampling Data.

ID	Hg Conc, mg/kg	ID	Hg Conc, mg/kg	ID	Hg Conc, mg/kg
2-1	0.20	7-4	3.3	11-15	0.14
2-2	0.00	7-5	2.7	11-16	0.61
2-3	0.00	7-6	49	11-17	5.49
2-4	1.80	7-7	53	11-18	8.03
2-5	-0.10	7-8	79	11-19	0.19
2-6	0.00	7-9	56	11-20	1.86
2-7	-0.10	7-10	46	12-1	30.00
2-8	0.10	7-11	0.1	12-2	0.48
2-9	4.80	7-12	0.5	12-3	7.99
2-10	-0.10	7-13	0	12-4	8.15
2-11	1.90	7-14	0.1	12-5	5.82
2-12	0.60	8-1	69	12-6	2.76
2-13	4.00	8-2	74	13-1	0.30
2-14	0.00	8-3	0.7	13-2	1.18
2-15	0.60	8-4	0.8	13-3	4.07
2-16	0.00	8-5	29	13-4	0.85
2-17	-0.10	8-6	68	13-5	4.92
2-18	-0.10	8-7	78	13-6	2.10
2-19	0.20	8-8	75	13-7	2.95
2-20	0.10	8-9	9.5	14-1	4.21
2-21	0.50	8-10	9.1	14-2	2.82
2-22	4.90	8-11	48	14-3	2.96
2-23	2.90	8-12	0.2	14-4	4.08
5-1	0.7	8-13	1.5	14-5	5.9
5-2	4.8	8-14	1.8	14-6	6.02
5-3	1.1	8-15	43	14-7	0.211
5-4	16	8-16	13	14-8	0.044
5-5	0.7	8-17	43	14-9	0.25
5-6	3.1	8-18	1.6	14-10	0.12
5-7	0.6	8-19	2.3	14-11	6.60
6-1	0.7	8-20	6.7		
6-2	1.9	11-1	1.05		
6-3	45	11-2	4.48		
6-4	7.2	11-3	1.46		
7A-1	68	11-4	0.136		
7A-2	12	11-5	7.15		
7A-3	64	11-6	0.756		
7A-4	32	11-7	0.035		
7A-5	53	11-8	0.023		
7A-6	31	11-9	0.42		
7A-7	56	11-10	0.083		
7A-8	39	11-11	4.7		
7-1	68	11-12	18		
7-2	0	11-13	5.24		
7-3	27	11-14	6.10		

Appendix E

Photographic Record of Central Facilities Area–04 Mercury Pond Work

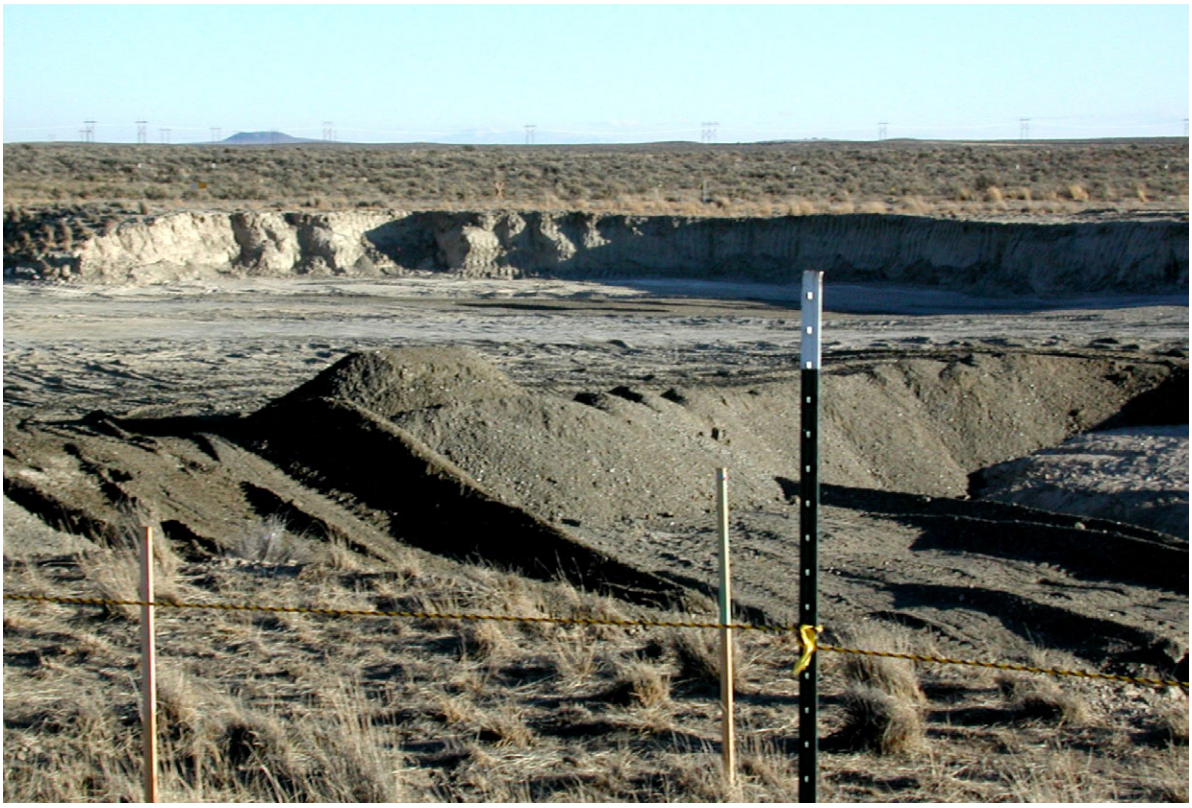

Photo E-1. Backfilling at CFA-04.

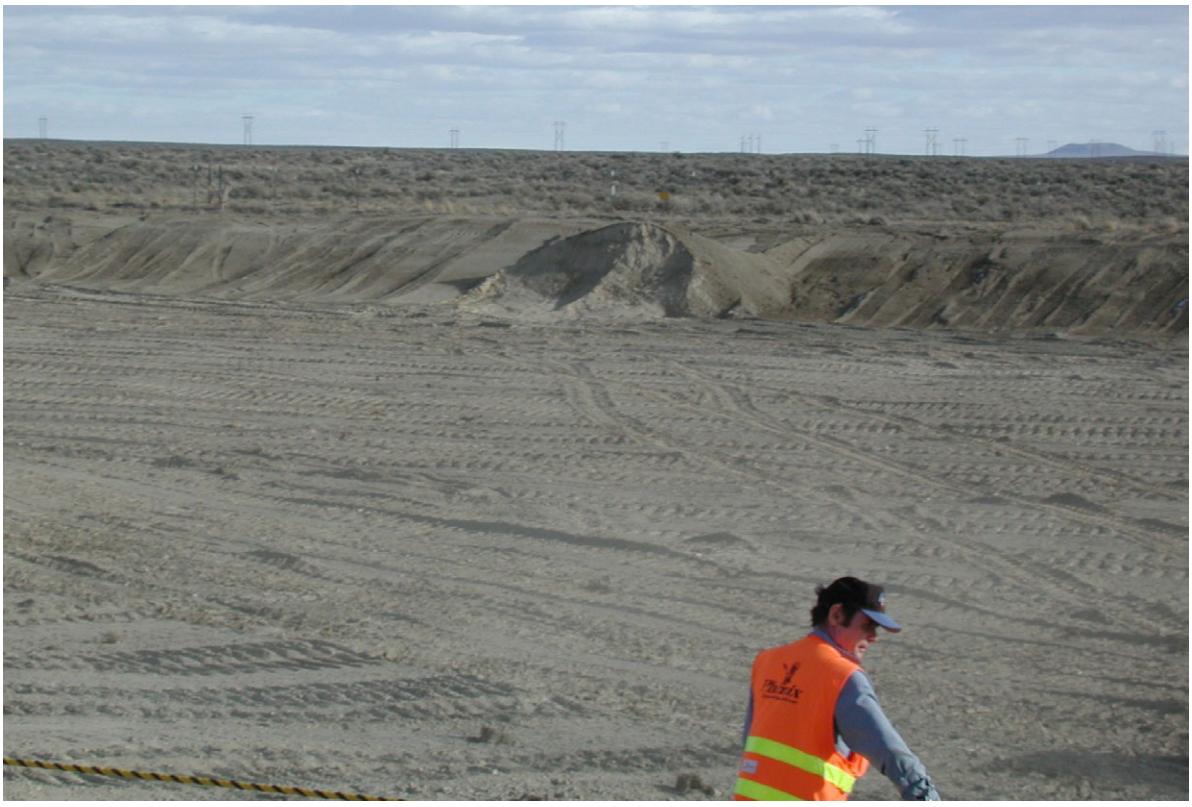

Photo E-2. Backfilling CFA-04.

Photo E-3. Excavation in Zones 6 and 7.

Photo E-4. Excavation in Zones 6 and 7.

Photo E-5. Excavation of Zone 5.

Photo E-6. Excavation of Zones 7 and 8

Photo E-7. Excavation of Zone 8.

Photo E-8. First load of CFA-04 soil to direct ICDF disposal.

Photo E-9. First load of CFA-04 soil to ICDF Treatment Storage Pad.

Photo E-10. Revegetation completed.

Photo E-11. Soil waiting shipment to ICDF.

Appendix F

Central Facilities Area-04 Mercury Pond Assessment of On-Basalt Remedial Action Sampling Results

Author – Robin VanHorn

CONTENTS

FIGURES

TABLES

ACRONYMS

CFA	Central Facilities Area
EPA	Environmental Protection Agency
FRG	final remediation goal
INEEL	Idaho National Engineering and Environmental Laboratory
UCL	upper confidence limit

Central Facilities Area-04 Mercury Pond Assessment of On-Basalt Remedial Action Sampling Results

1. OVERVIEW

The post-remediation confirmation field sampling at the CFA-04 mercury pond is discussed in Appendix D (CFA-04 Mercury Pond Remedial Action Sampling Results) of this report. The field results were used to identify areas that required further excavation and to provide data to evaluate the effectiveness of the soil excavation in removing mercury-contaminated soils to the remediation goal (8.4 mg/kg).

Field samples were collected throughout the entire excavated area of the pond, both during and after the excavation process. Areas where excavation did not reach the basalt interface were assessed in Appendix D (John Giles). This evaluation of the confirmation sampling data concluded that at the 95% confidence level, the average mercury contamination in the soils remaining at the CFA-04 Pond is less than the final remediation goal (Appendix D, John Giles). Information concerning site location, background, description, nature, and extent of contamination are included in this assessment.

This appendix evaluates the results of the sampling both on- and off-basalt using the approach documented in the *Evaluation of Residual Mercury at the CFA-04 (CFA-674) Pond* (VanHorn and Stacey 2003) presented in Attachment F1. The assessment of this data will determine the institutional control requirements if any, that may be required in this area.

2. SAMPLING LOCATIONS AND RESULTS

The confirmation sampling summary presented in Appendix C (Preremediation Sampling Summary Report) discusses preremediation sampling results, and the confirmation sampling that is included in the *Field Sampling Plan for the Central Facilities Area-04 Pond Remedial Action* (DOE-ID 2003a). This includes information about the sampling procedures, locations, and assessment. For this assessment, the sampling activities at CFA-04 were evaluated to assess mercury concentration on the basalt and to compare this with an overall average mercury concentration at the CFA-04 site.

As shown in Figures 1 through 6, field samples were collected throughout the entire excavated area of the pond after the excavation process. For assessment, these areas were broken into on- and off-basalt. Figures 1 through 4 present the locations and concentrations of those confirmation and quality confirmation samples that were collected off-basalt. Figures 3 and 4 present the locations and concentrations of the eight quality control samples used to demonstrate the correlation between the field analyzer and offsite laboratory data. Figures 5 and 6 present the locations and concentration of those samples collected on-basalt. As shown in Figures 1 and 5, Areas 11 and 14 consist of samples both on- and off-basalt. The data from these areas were separated appropriately for assessment.

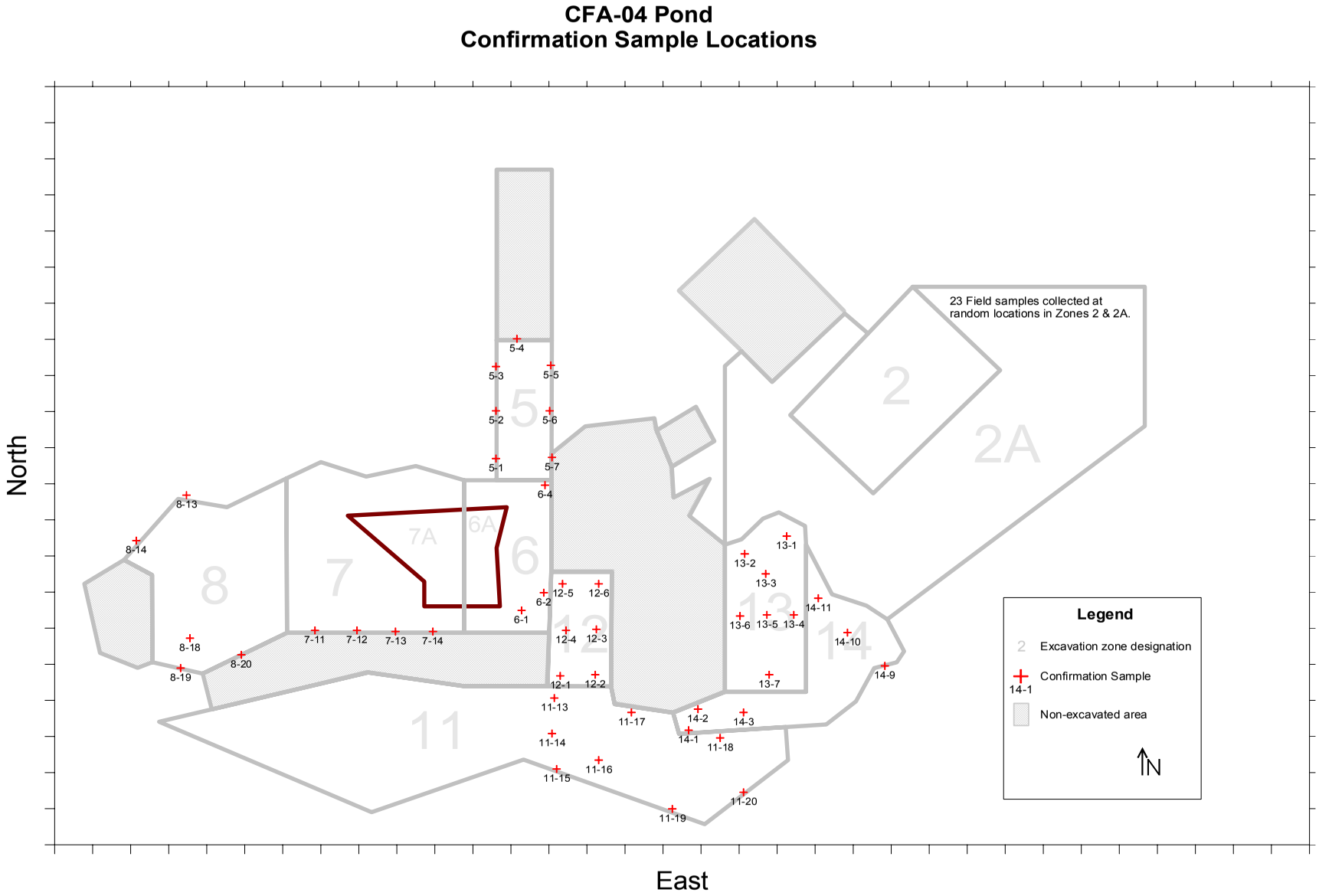

Figure 1. Central Facilities Area, CFA-04 Pond confirmation sampling locations.

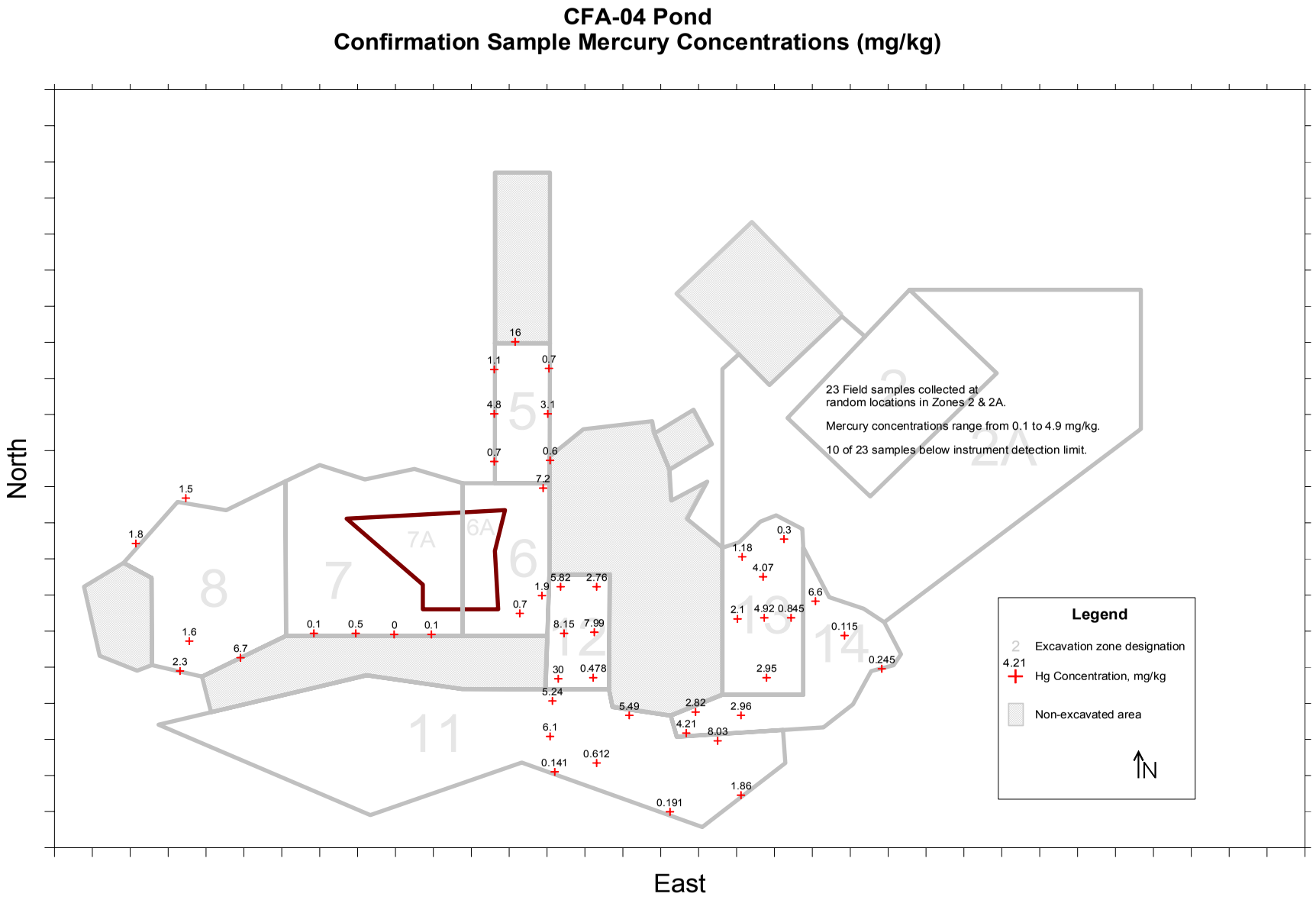

Figure 2. Central Facilities Area, CFA-04 Pond confirmation sample mercury concentrations (mg/kg).

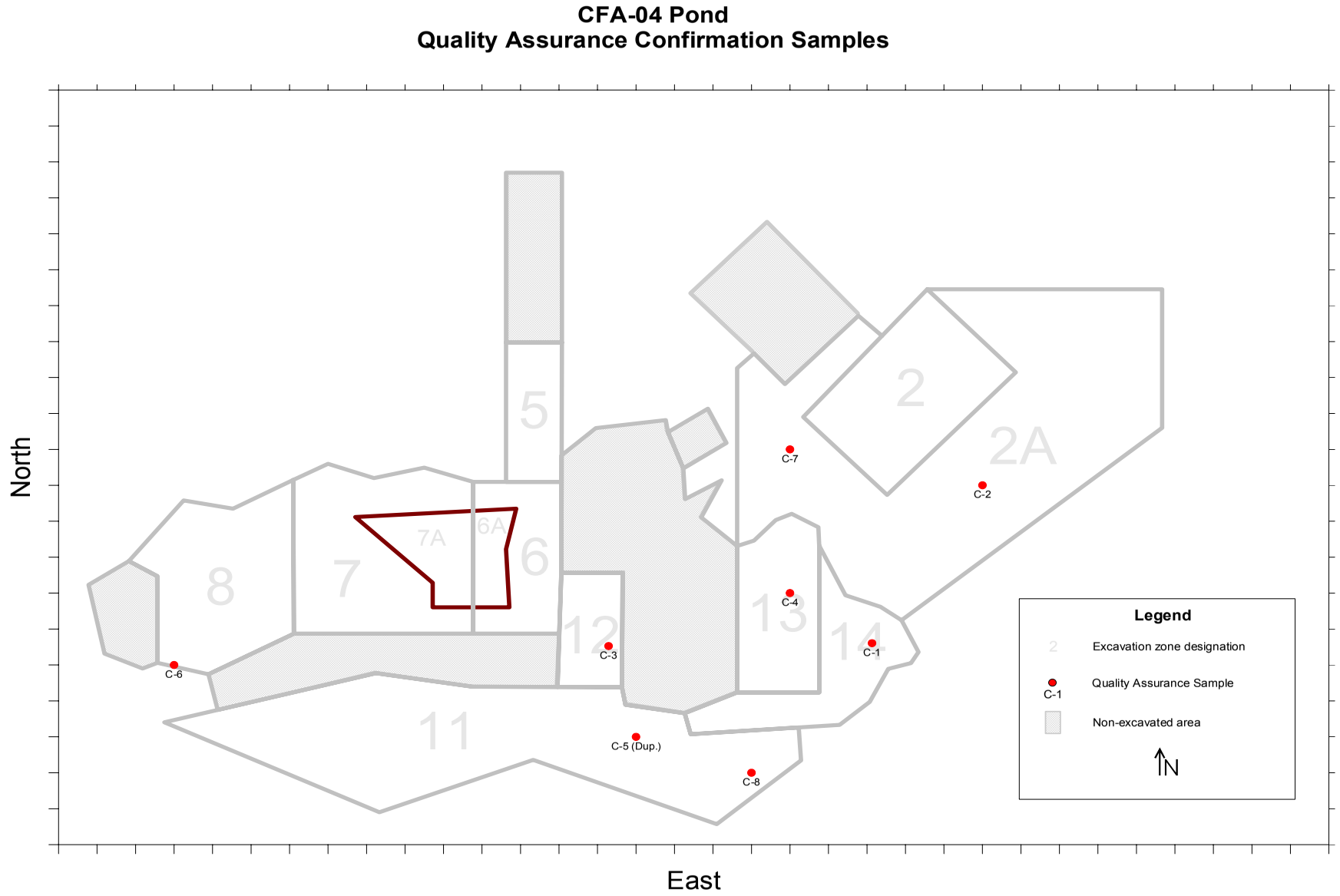

Figure 3. Central Facilities Area, CFA-04 Pond quality assurance confirmation sample locations.

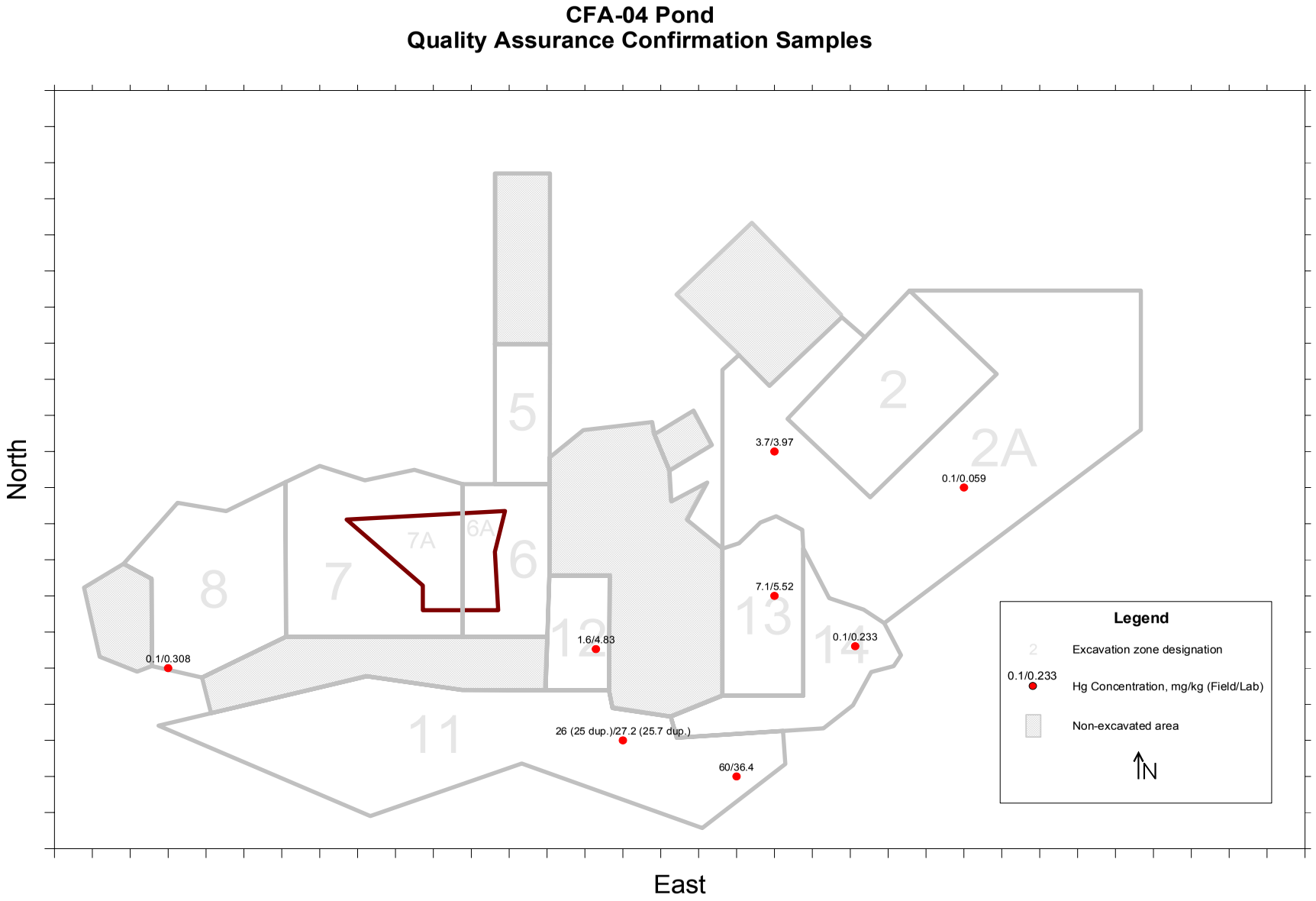

Figure 4. Central Facilities Area, CFA-04 Pond quality assurance confirmation sample results.

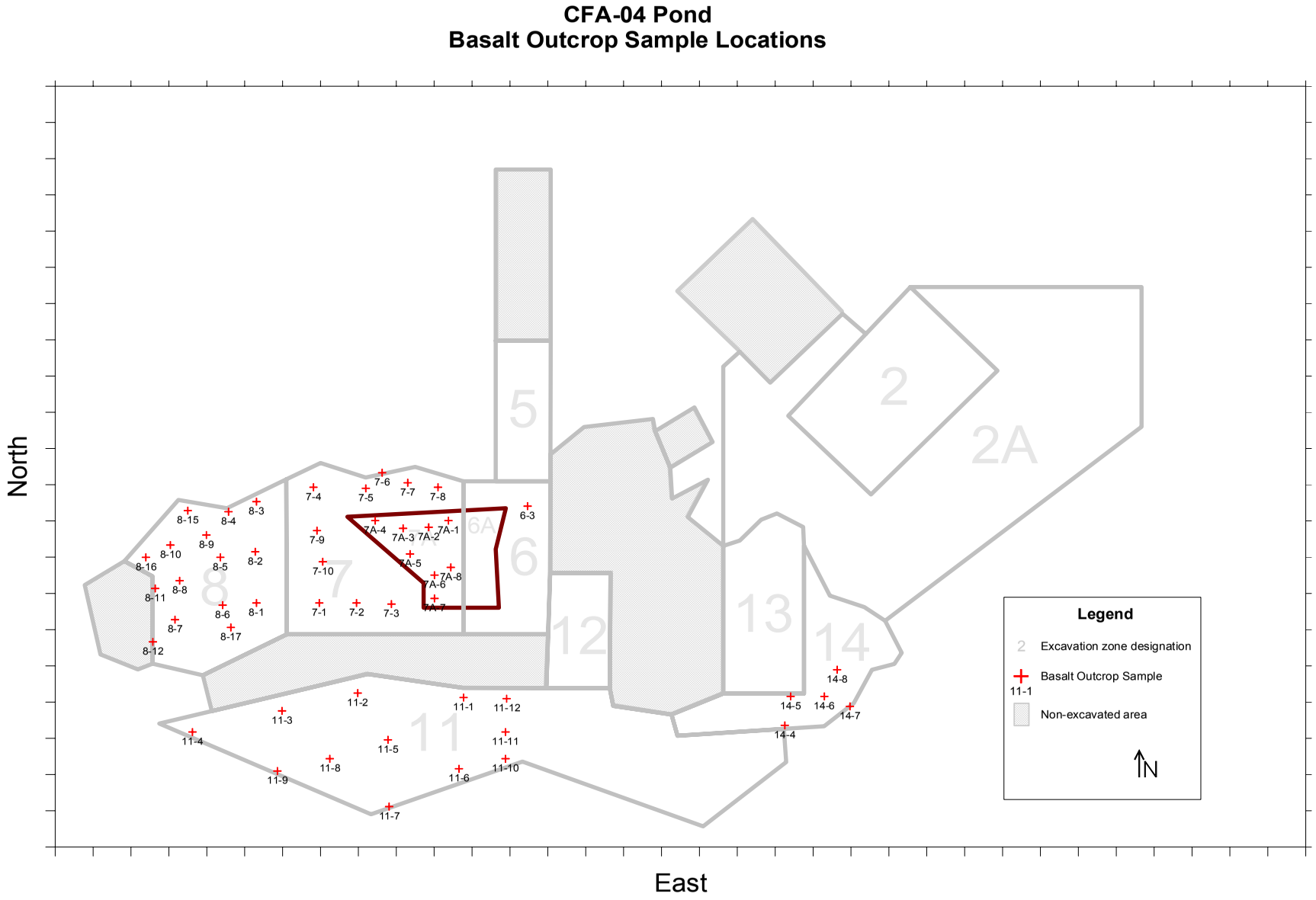

Figure 5. Central Facilities Area, CFA-04 Pond basalt outcrop sample locations.

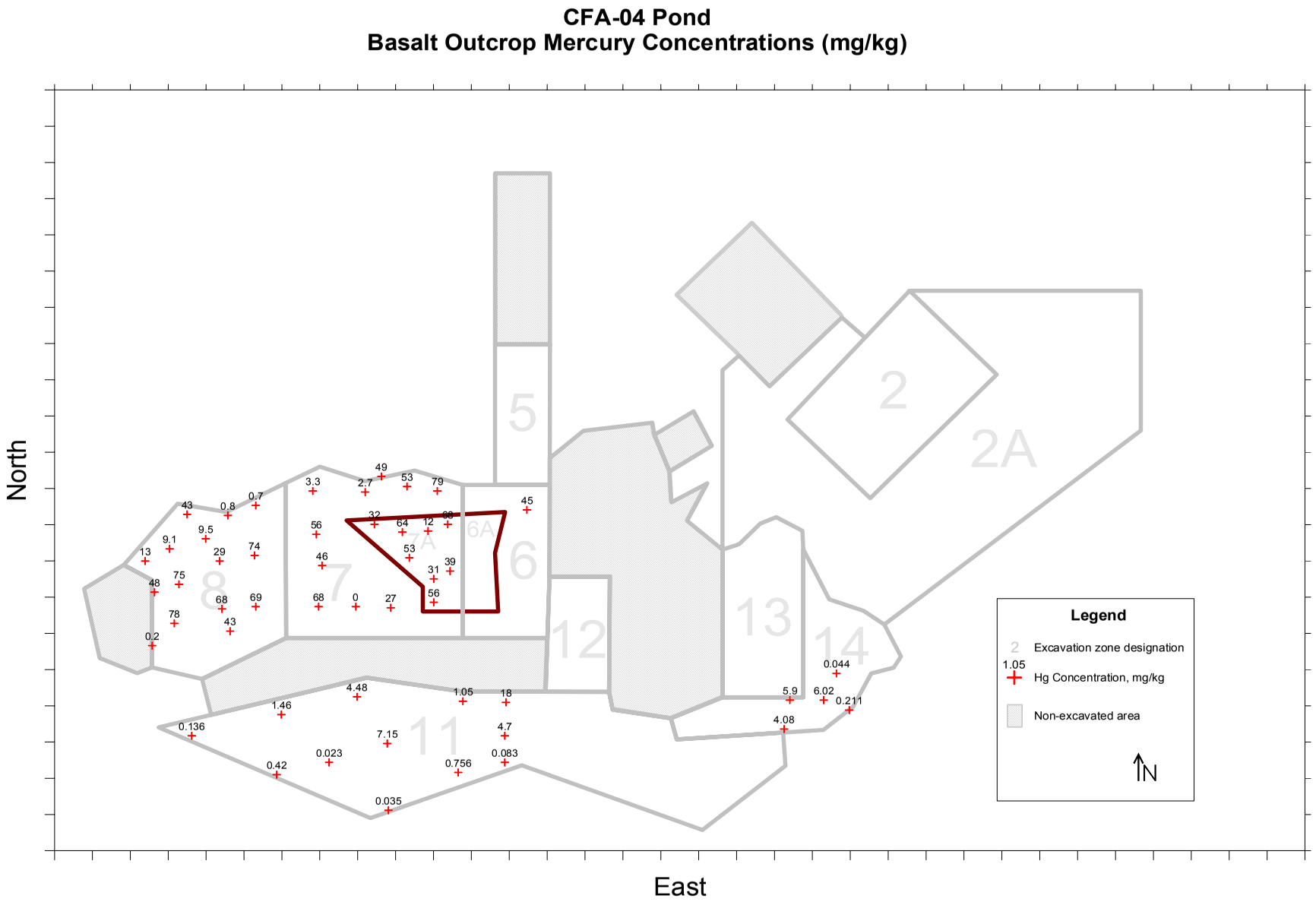

Figure 6. Central Facilities Area, CFA-04 Pond basalt outcrop mercury concentrations (mg/kg).

3. DATA EVALUATION

The sampling results are tabulated in Attachment F-2 of this report. The data were summarized by area based on the following rationale:

- Area 2 (including 2A). Is a windblown area (Appendix C, John Giles). Twenty-three samples (2-1 through 2-23) were collected at random locations in Areas 2 and 2A. Two quality assurance samples were also collected within this area. Mercury concentrations were below the FRG and range from 0.1 to 4.9 mg/kg. All samples will be considered off-basalt.

- Area 5. Area 5 was excavated to basalt; Samples 5-1 through 5-7 were collected from the midpoint of the side slopes. These were used to represent the on-basalt sampling.

- Area 6. Area 6 has one sample on-basalt and four off. All will be considered on-basalt.

- Area 7. Four samples, 7-11 through 7-14, were collected on the side slope and not on the basalt. These were all under the cleanup goal and for the purpose of this assessment, were considered part of Area 10 (next to Area 7).

- Area 8. Included in the 21 samples collected within this area, five confirmation samples were collected within this area as shown in Figures 6 and 7. Samples 8-14 and 8-13 were collected from the side slope and were below the cleanup goal (1.8 mg/kg). These two samples were eliminated. The other three samples (8-18 to 8-20), although they are on top of soil (not basalt), will be included with the other samples on top of basalt for this assessment. One quality assurance confirmation sample was collected within Area 8 on soil. It was included in the on-basalt data set.

- Area 11. This area includes locations at both on- and off-basalt. This estimate assumes that 60% of the area is on-basalt and 40% of the area is off-basalt. Samples 11-1 through 11-12 were taken on-basalt and will be referred to as 11B. Samples 11-13 through 11-20 and two quality assurance samples were collected off-basalt and will be referred to as 11R.

- Area 12. This area is located off-basalt. Seven samples were taken from this area: Samples 12-1 to 12-6 and one quality assurance sample.

- Area 13. This area is located off-basalt. Eight samples were taken from this area: Samples 13-1 to 13-7, and one quality assurance sample.

- Area 14. As shown in Figures 1, 2, 5, and 6, this area has locations both on- and off-basalt. For this assessment, it is assumed that 30% is on-basalt. The on-basalt assessment (referred to as 14B) will include Samples 14-4 through 14-7. The off-basalt assessment (referred to as 14R) will include Samples 14-1 through 14-3, 14-9 through 14-11, and one quality assurance sample.

3.1 Test for Normality

EPA (2002) recommends the Sharpiro-Wilk Test for Normality (the W Test). The results of this test are summarized in Table 1. From this assessment, most of the data from Areas 2 (including 2A), 5, 6, 11R, 11B, and 12 appear to be lognormally distributed. Although Area 8 does not appear to fit well into either distribution, for conservatism it was assessed as lognormal.

Areas 7, 13, 14R, and 14B appear to be normally distributed when tested using the W Test. However, the meaning of this in association with other areas that are lognormally distributed indicates there may be some other underlying distributions. However, the W Test results were accepted, and these areas were assessed as normally distributed.

Table 1. Test for normal/lognormal distribution.

Location	Number of Samples	Raw Data W-Value	P-Value	Normal Distribution	Ln-transformed W-value	P-value	Lognormal Distribution
Area 2a	25	0.6724	0.0000	No	0.8149	0.0030	Use
Area 5	7	0.6699	0.0017	No	0.8689	0.1877	Yes
Area 6 a	4	0.7374	0.0304	No	0.9773	0.8567	Yes
Area 7 a	18	0.9361	0.2530	Yes	0.6276	0.0000	No
Area 8	19	0.8240	0.0020	No	0.8755	0.0169	Use
Area 11R	10	0.7248	0.0021	No	0.9275	0.4079	Yes
Area 11B	12	0.6606	0.0002	No	0.9600	0.7290	Yes
Area 12	7	0.7255	0.0068	No	0.9314	0.5816	Yes
Area 13	8	0.9389	0.6042	Yes	0.9186	0.4240	No
Area 14R	7	0.8794	0.2322	Yes	0.8429	0.1080	No
Area 14B	5	0.8184	0.1117	Yes	0.8088	0.0941	No

a. Areas include both 2 and 2A, 6 and 6A, and 7 and 7A.

3.2 Calculation of the 95% Upper Confidence Limit

EPA (1992) recommends the use of the 95% upper confidence level (UCL) on the mean to calculate an average concentration that represents "a reasonable estimate of the concentration likely to be contacted over time" (EPA 1989). The 95% upper confidence level defines a value that equals or exceeds the true mean 95% of the time. For normal distribution, the 95% upper confidence level is generally based on the Student's t-statistic. For lognormal data, EPA recommends the Land method using the H–statistic (Land 1971). For nondetects that make up less than 15% of the data, it is recommended to replace the nondetects with one-half the detect limit, the detection limit, or a very small number (EPA 2002). For this assessment, the zero and negative values were changed to the INEEL mean background for mercury of 0.03 mg/kg, which is small compared to the values detected and the cleanup goal (Rood et al., 1996). These data are noted in Attachment F2 of this Appendix. The calculated 95% upper confidence levels for the lognormally distributed data are presented in Table 2 and the normally distributed data in Table 3.

Table 2. Upper confidence limit of 95% calculation and comparison with maximum concentration for lognormally distributed data.

Area	Mean (Ln)	Count	Stddev	H-Statistic	Max	UCL	Concentration
Area 2	-1.38	25	2.10	4.17	4.90	1.36E+01	4.90E+00
Area 5	0.62	7	1.24	4.40	16.00	3.75E+01	1.60E+01
Area 6	1.52	4	1.80	16.01	45.00	3.91E+08	4.50E+01
Area 8	2.27	19	2.03	4.26	78.00	5.80E+02	7.80E+01
Area 11R	1.07	10	1.91	5.18	30.00	4.90E+02	3.00E+01
Area 11B	-0.37	12	2.17	5.34	18.00	2.41E+02	1.80E+01
Area 12	1.60	7	1.26	4.46	30.00	1.09E+02	3.00E+01

Table 3. Upper confidence limit of 95% calculation comparison with maximum concentrations for normally distributed data.

Area	Mean	Count	Stddev	Max	UCL	Concentration
Area 7	41.06	18	24.31	79.00	5.32E+01	5.32E+01[a]
Area 13	2.74	8	1.85	5.52	4.37E+00	4.37E+00[a]
Area 14R	2.45	7	2.45	6.60	4.70E+00	4.70E+00[a]
Area 14B	3.25	5	2.95	6.02	6.92E+00	6.02E+00

a. From upper confidence limit.

As shown in Tables 2 and 3, the maximum was less than the 95% upper confidence limit at most areas. The use of the maximum for this data will overestimate the average concentration in each area and subsequently, the total. Land's approach to calculating the 95% upper confidence limit is known to be sensitive to deviations from lognormality and may commonly yield estimated upper confidence limits substantially larger than necessary when distributions are not truly lognormal if the variance or skewness is large, or the samples sizes are less than 30. Singh et al. (1997) found that the method can be impractical even when the underlying distribution is lognormal. However, since it is known to be conservative, it is recommended as a first cut.

3.3 Assessment Of The Concentration Across The Site

The average concentration was assessed using the approach documented in the *Evaluation of Residual Mercury at the CFA-04 (CFA-674) Pond* (VanHorn and Stacey 2003). This white paper, presented in Attachment F1, used an approach to estimate the amount of contaminated soil within the basalt fractures, and to use this value to calculate the average mass and concentration of the mercury remaining in the soil at the CFA-04 Pond for comparison to the final remediation goal (FRG).

An average soil concentration is used in the evaluation of a contaminated site in assessing both human and ecological risk. For the human health resident intrusional scenario, a basement of 10 ft is assumed and the 95% upper confidence limit of the mean is calculated from all samples collected. Based on EPA guidance (EPA 1992), the minimum of either the 95% upper confidence limit or the maximum detection will be used in the assessment. The ecological risk assessment uses similar assumptions in the assessment of risk to ecological receptors. CFA-04 is a dry pond with a 9-ft deep depression. Remediation activities will only replace any soil that was removed and will not fill the depression. To calculate an average soil concentration through a 10-ft depth, it was conservatively assumed that the soil surface area of the pond is level. The volume of contaminated soil to be removed and replaced at the CFA-04 Pond is presented in the *Waste Area Group 4 Remedial Design/Remedial Action Work Plan, CFA-04 Pond Mercury-Contaminated Soils, Operable Unit 4-13* (DOE-ID 2003b) by areas. Table 4 summarizes the excavation depth to basalt, and volumes and masses of soil to be removed by areas where the basalt is within the 10-ft range from the surface. This includes Areas 5, 6 (which includes 6A), 7 (which includes 7A), 8, 11B, and 14B.

The volume of contaminated soil remaining was assumed to be 10% of the basalt layer located within the 10-ft zone. These volumes were used to determine the mass of contaminated soil remaining in the basalt fractures following remediation efforts. The assumption of 10% soil within the basalt is considered conservative by those individuals inspecting the site during remediation.[a] Even a reduction to 5% would result in an 8% reduction in the average concentration. These areas on-basalt therefore contribute significantly to the total mass of the residual mercury.

a. Appendix D, John Giles Report; and Robin VanHorn personal communication with John Giles, February 2004.

The *Evaluation of Residual Mercury at the CFA-04 (CFA-674) Pond* (VanHorn and Stacey 2003) initially assumed that all contaminated soil above basalt would be removed. However, due to difficulties with remediating soil above basalt, some soil remained. Therefore, in this assessment it was conservatively assumed that 0.5 ft of contaminated soil would remain in the areas on-basalt. To calculate the soil volume remaining on top of the basalt at each area, the total site area was multiplied by the 0.5-ft depth. This was added to the volume assumed to be within the basalt fractures to produce a total volume of soil remaining in cubic yards. This difference from the initial evaluation adds a considerable amount of contaminated soil to the final result.

The mass of each residual soil was calculated by multiplying the volume by the standard soil density of 1.5 g/cm^3 for INEEL soil.The mass of the residual mercury at each area was determined by multiplying the mass of the residual soil in kilograms by the mercury soil concentration (lower of either the maximum or 95% upper confidence limit as presented in Tables 2 and 3). The average concentration of mercury in the soil for each area was then calculated by dividing the total mass of mercury by the total mass of soil (assuming not clean soil).

Table 4 presents the average residual mercury concentration (in soil calculation for the on-basalt areas of the CFA-04 Pond. For these areas alone, the residual mercury concentration is 44.4 mg/kg, which is over the remediation goal. However, as previously shown (VanHorn and Stacey 2003), the residual mercury concentration is more appropriately calculated using the total area of the pond.

When the other remediated areas are included, the average concentration is reduced. As shown in Table 5, the volume of soil below the remediation depth is calculated by subtracting the volume of the soil removed (excavated) from the total volume. To determine the amount of residual mercury, the maximum or 95% upper confidence limit of the mean is multiplied by the mass of the remaining soil. The last line of this table presents the total mass of mercury divided by the total mass of clean soil and the total mass of soil containing residual contamination. The average mercury concentration, assuming no clean fill for the whole pond area, is calculated to be 9.47 mg/kg (Table 5). When the 10,000 yd^3 of clean fill is added to the assessment, as shown at the bottom of Table 5, the average concentration of residual mercury within the pond site is 7.3 mg/kg.

4. DISCUSSION AND SUMMARY

The initial calculation of the average concentration of the residual mercury remaining in the CFA-04 pond soils, presented in *Evaluation of Residual Mercury at the CFA-04 (CFA-674) Pond* (VanHorn and Stacey 2003), was based on the assumption that the basalt would be vacuumed. However, as the remedial action progressed, it was readily apparent that the nature of the basalt underlying the pond would not allow for cleaning using any method other than conventional excavation with heavy equipment.

Due to the limitations in the excavation, approximately 6-in. of soil was assumed to remain on the basalt. The key underlying assumptions are as follows:

- The contaminated soil volume extended to a depth of 10 ft below preexcavation grade.
- The volume of soil excavated in each zone would be replaced (i.e., excavated area brought back to preconstruction grade) with clean fill material.

Table 4. Assessment maximum or 95% upper confidence limit concentrations in areas on-basalt at CFA-04 Pond.

	Total Area (ft^2)[a]	Excavation Depth (ft)[a]	Concentration of Mercury in Soil Remaining (mg/kg)	Volume Below Remediation Depth (to 10 ft) Assumed Volume of Basalt (yd^3)	Volume of Soil Above Basalt (Assume 5 ft) (yd^3)	Volume of Soil Within the Fractures (yd^3)[b]	Total Volume of Soil Remaining (yd^3)	Mass of Contaminated Soil Remaining (kg)	Mass of Mercury (mg)	Average Concentration of Mercury in Soil (mg/kg)
Area 6	6.02E+03	6	4.50E+01	8.92E+02	1.11E+02	8.92E+01	2.01E+02	2.30E+05	1.04E+07	
Area 7	1.31E+04	5	5.31E+01	2.43E+03	2.43E+02	2.43E+02	4.85E+02	5.56E+05	2.96E+07	
Area 8	1.01E+04	4	7.80E+01	2.24E+03	1.87E+02	2.24E+02	4.11E+02	4.72E+05	3.68E+07	
Area 11	1.22E+04	3	1.80E+01	3.16E+03	2.26E+02	3.16E+02	5.41E+02	6.21E+05	1.12E+07	
Area 14	2.78E+03	5	6.02E+00	5.15E+02	5.15E+01	5.15E+01	1.03E+02	1.18E+05	7.11E+05	
All on-Basalt Area Totals								2.00E+06	8.86E+07	4.44E+01

a. Total area and excavation depth taken from DOE/ID-11028 (DOE-ID 2003b). This information used to calculate volume below remediation.
b. Volume of soil within fractures is from INEEL/EXT-02-01476 (VanHorn and Stacey 2003); data for Hg concentrations are from Appendix D (John Giles) of this document.

Table 5. Calculation of average concentrations across the pond area (using approach from VanHorn and Stacey 2003).

	Total Area (ft^2)	Excavation Depth (ft)	Total volume of Soil Remaining (to 10 ft) (yd^3)	Concentration of Mercury in Soil Remaining (mg/kg)	Mass of Contaminated Soil Remaining (kg)	Mass of Mercury (mg)	Average Concentration of Mercury in Soil (mg/kg)
Area 2	9.43E+03	1	3.14E+03	4.90E+00	3.60E+06	1.77E+07	
Area 2a	5.61E+04	0.5	1.97E+04	4.90E+00	2.26E+07	1.11E+08	
Area 5	3.78E+03	1	1.96E+02	1.60E+01	2.25E+05	3.60E+06	
Area 6	6.02E+03	6	2.01E+02	4.50E+01	2.30E+05	1.04E+07	
Area 7	1.31E+04	5	4.85E+02	5.31E+01	5.56E+05	2.95E+07	
Area 8	1.01E+04	4	4.11E+02	7.80E+01	4.72E+05	3.68E+07	
Area 11R	8.12E+03	3	2.11E+03	3.00E+01	2.41E+06	7.24E+07	
Area 11B	1.22E+04	3	5.41E+02	1.80E+01	6.21E+05	1.12E+07	

Table 5. (continued).

	Total Area (ft^2)	Excavation Depth (ft)	Total volume of Soil Remaining (to 10 ft) (yd^3)	Concentration of Mercury in Soil Remaining (mg/kg)	Mass of Contaminated Soil Remaining (kg)	Mass of Mercury (mg)	Average Concentration of Mercury in Soil (mg/kg)
Area 12	3.24E+03	2	9.60E+02	3.00E+01	1.10E+06	3.30E+07	
Area 13	5.63E+03	2	1.67E+03	4.37E+00	1.91E+06	8.36E+06	
Area 14R	6.49E+03	5	1.20E+03	4.72E+00	1.38E+06	6.51E+06	
Area 14B	6.49E+03	5	1.03E+02	6.02E+00	1.18E+05	7.11E+05	
All Area Totals					3.53E+07	3.41E+08	
Added clean fill soil			1.00E+04	NA	1.15E+07	NA	
All Area Totals with added soil					4.67E+07	3.41E+08	7.30E+00

- For those zones where the excavation depth was shallower than 10 ft due to basalt ridges, it was assumed that 10% of the volume occupied by the basalt ridge was fractured and filled with mercury-contaminated soil, as observed at various on-Site locations (references provided in VanHorn and Stacey 2003).

- Due to limitations in the excavation methods, a 6-in. layer of soil will remain at the soil/basalt interface.

When initially assessed, it appeared that allowing 6 in. of soil to remain on the basalt would result in an average concentration across the remediation that would be below the FRG without fill. However, because the concentration of mercury remaining in the soil was higher than anticipated in almost every area, the evaluation of the calculated average is above the FRG (9.2 mg/kg) unless the fill is considered, which reduces the average concentration to 7.2 mg/kg.

The FRG was driven by ecological concerns. The remedial goal for human health was determined to be 9.4 mg/kg and 8.4 mg/kg for ecological receptors. The primary pathway of concern for exposure to mercury at the CFA-04 pond by human receptors was ingestion of homegrown produce (INEEL 2002). This was driven by mercury contamination in both the groundwater and the soil. In *Evaluation of Residual Mercury at the CFA-04 (CFA-674) Pond* (VanHorn and Stacey 2003), the groundwater concentrations resulting from surface and near-surface sources were estimated using the computer code GWSCREEN (Rood 1994). The total mass of each contaminant considered in the GWSCREEN modeling was calculated by summing the contaminant masses from the retained site. The contaminant mass at the site was derived by multiplying the contaminant mean concentration (or maximum if appropriate) by the mass of contaminated soil at the site. The total mass of mercury used in the GWSCREEN calculation for the CFA-04 pond FRG was 5.39E+08 mg. As shown in Table 5, based on post-remediation sampling the total mass of mercury is lower (3.52E+08 mg), ensuring that mercury from groundwater contamination is not a concern. This assessment was considered conservative since the migration of mercury contamination through the soil column to groundwater is unlikely as the absorbency for mercury to soil is high (VanHorn and Stacey 2003). To date, groundwater monitoring at the CFA downgradient wells of CFA-MON-A-001, -002, and –003, as well as USGS-OBS-A-127, has not detected any mercury using a detection limit of 0.1 ug/liter (the maximum contaminant level [MCL] is 2 ug/L).

The FRG is an average concentration across the site; therefore, it is acceptable that higher concentrations may be left in some locations (hot spots), mostly at depth. Foraging exposure to ecological receptors is appropriately evaluated as an average. Small fractures within the basalt have limited use to most ecological receptors for habitat; however, the type of depression left from the remediation accumulates water and provides preferred habitat for some species.

As part of the long-term ecological monitoring plan (INEEL 2004), plants and animals will be periodically evaluated in the CFA area. Mercury is a contaminant of concern at many sites and will be retained for evaluation across the INEEL. If elevated levels of mercury are detected in either the vegetation or animals at CFA, the CFA-04 pond will be included in any further assessment.

5. REFERENCES

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Attachment F1

Evaluation of Residual Mercury at the CFA-04 (CFA-674) Pond

INEEL/EXT-02-01476

TO VIEW ATTACHMENT F1 SEE:

INEEL/EXT-02-01476, REV.00

Attachment F2

Post-Remediation Sampling Results by Area

Attachment F2

Post-Remediation Sampling Results by Area

Table F1-1. Post-remediation sampling results by area.

ID	Easting	Northing	Hg Concentration, mg/kg	LN of Hg Concentration	Comments
Area 2 Wind-blown					
2-1			0.20	-1.61	
2-2			0.03	-3.51	
2-3			0.03	-3.51	
2-4			1.80	0.59	
2-5			0.03	-3.51	
2-6			0.03	-3.51	
2-7			0.03	-3.51	
2-8			0.10	-2.30	
2-9			4.80	1.57	
2-10			0.03	-3.51	
2-11			1.90	0.64	
2-12			0.60	-0.51	
2-13			4.00	1.39	
2-14			0.03	-3.51	
2-15			0.60	-0.51	
2-16			0.03	-3.51	
2-17			0.03	-3.51	
2-18			0.03	-3.51	
2-19			0.20	-1.61	
2-20			0.10	-2.30	
2-21			0.50	-0.69	
2-22			4.90	1.59	
2-23			2.90	1.06	
C-2			0.06	1.59	
C-7			3.97	1.59	
Area 5 Off-Basalt					
5-1	293340	677467	0.7	-0.36	All side slope
5-2	293340	677500	4.8	1.57	
5-3	293340	677531	1.1	0.10	
5-4	293354	677550	16	2.77	

Table F1-1. (continued).

ID	Easting	Northing	Hg Concentration, mg/kg	LN of Hg Concentration	Comments
5-5	293376	677532	0.7	-0.36	
5-6	293375	677500	3.1	1.13	
5-7	293377	677468	0.6	-0.51	
Area 6 On-Basalt					
6-1	293357	677362	0.7	-0.36	
6-2	293372	677375	1.9	0.64	
6-3	293362	677435	45	3.81	
6-4	293372	677449	7.2	1.97	
Area 7 On-Basalt					
7A-1	293309	677425	68	4.22	
7A-2	293296	677421	12	2.48	
7A-3	293279	677420	64	4.16	
7A-4	293261	677425	32	3.47	
7A-5	293284	677402	53	3.97	
7A-6	293300	677388	31	3.43	
7A-7	293300	677371	56	4.03	
7A-8	293311	677393	39	3.66	
7-1	293224	677368	68	4.22	
7-2	293249	677368	0.03	-3.51	Originally zero
7-3	293272	677368	27	3.30	
7-4	293220	677448	3.3	1.19	
7-5	293255	677447	2.7	0.99	
7-6	293266	677458	49	3.89	
7-7	293283	677451	53	3.97	
7-8	293303	677448	79	4.37	
7-9	293223	677418	56	4.03	
7-10	293227	677397	46	3.83	
Area 7 Side Slope, not Included					
7-11	293221	677348	0.1	-2.30	Side slope
7-12	293249	677348	0.5	-0.69	Side slope
7-13	293274	677348	0.03	-3.51	Side slope (originally zero)
7-14	293299	677348	0.1	-2.30	Side slope
Area 8 On-Basalt					
8-1	293183	677368	69	4.23	
8-2	293182	677404	74	4.30	

Table F1-1. (continued).

ID	Easting	Northing	Hg Concentration, mg/kg	LN of Hg Concentration	Comments
8-3	293183	677438	0.7	-0.36	
8-4	293164	677431	0.8	-0.22	
8-5	293159	677400	29	3.37	
8-6	293160	677367	68	4.22	
8-7	293129	677357	78	4.36	
8-8	293132	677384	75	4.32	
8-9	293150	677415	9.5	2.25	
8-10	293126	677408	9.1	2.21	
8-11	293116	677378	48	3.87	
8-12	293114	677342	0.2	-1.61	
8-15	293137	677432	43	3.76	
8-16	293110	677400	13	2.56	
8-17	293166	677352	43	3.76	
8-18	293139	677343	1.6	0.47	bottom on soil
8-19	293133	677322	2.3	0.83	bottom on soil
8-20	293173	677332	6.7	1.90	bottom on soil
C-6			0.308	-1.18	bottom on soil
			Area 8 Side Slope, Not Included		
8-13	293137	677442	1.5	0.41	Side slope
8-14	293104	677411	1.8	0.59	Side slope
			Area 11 On-Basalt		
11-1	293319	677303	1.05	0.05	
11-2	293250	677306	4.48	1.50	
11-3	293200	677294	1.46	0.38	
11-4	293141	677279	0.136	-2.00	
11-5	293270	677274	7.15	1.97	
11-6	293316	677254	0.756	-0.28	
11-7	293270	677228	0.035	-3.35	
11-8	293231	677261	0.023	-3.77	
11-9	293197	677252	0.42	-0.87	
11-10	293347	677261	0.083	-2.49	
11-11	293347	677279	4.7	1.55	
11-12	293348	677302	18	2.89	

Table F1-1. (continued).

ID	Easting	Northing	Hg Concentration, mg/kg	LN of Hg Concentration	Comments
			Area 11 Off-Basalt		
11-13	293379	677302	5.24	1.66	
11-14	293377	677277	6.10	1.81	
11-15	293380	677252	0.14	-1.96	
11-16	293408	677259	0.61	-0.49	
11-17	293429	677292	5.49	1.70	
11-18	293488	677274	8.03	2.08	
11-19	293456	677225	0.19	-1.66	
11-20	293503	677236	1.86	0.62	
C-5			27.2	3.30	Confirmation sample, laboratory result used
C-8			36.4	3.59	Confirmation sample, laboratory result used
			Area 12 Off-Basalt		
12-1	293382	677317	30.00	3.40	
12-2	293405	677318	0.48	-0.74	
12-3	293406	677349	7.99	2.08	
12-4	293386	677348	8.15	2.10	
12-5	293384	677381	5.82	1.76	
12-6	293408	677381	2.76	1.02	
C-3			4.83	1.57	
			Area 13 Off-Basalt		
13-1	293531	677414	0.30	-1.20	
13-2	293504	677401	1.18	0.17	
13-3	293518	677388	4.07	1.40	
13-4	293536	677359	0.85	-0.17	
13-5	293518	677359	4.92	1.59	
13-6	293501	677358	2.10	0.74	
13-7	293520	677318	2.95	1.08	
C-4			5.52	1.71	
			Area 14 Off-Basalt		
14-1	293467	677279	4.21	1.44	
14-2	293473	677294	2.82	1.04	
14-3	293503	677292	2.96	1.09	
14-9	293596	677324	0.25	-1.41	

Table F1-1. (continued).

ID	Easting	Northing	Hg Concentration, mg/kg	LN of Hg Concentration	Comments
14-10	293571	677347	0.12	-2.16	
14-11	293552	677371	6.60	1.89	
C-1			0.23	-1.46	
			Area 14 On-Basalt		
14-4	293531	677284	4.08	1.41	
14-5	293535	677304	5.9	1.77	
14-6	293557	677304	6.02	1.80	
14-7	293574	677297	0.211	-1.56	
14-8	293566	677322	0.044	-3.12	